MARINE ENGINEERING.

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GROUP OF SIX 31-KNOT YARROW DESTROYERS FOR THE JAPANESE NAVY.

Japan has made such extraordinary progress in naval matters in a very few years that she can now be accurately classed as a first-rate naval power. In modern vessels of every type she can make a respectable showing, from half a dozen battleships afloat (none older than 1896, and ranging in size from 12,300 tons to 15,200 tons) down to torpedo boats of the most modern type. Her experiences in the war with China have been put to good use in the design of vessels for her special needs.

Among the latest additions to her navy is a group of six torpedo boat destroyers, each having a trial speed in excess of 31 knots. These boats were constructed at the Poplar yard of Yarrow & Co., the well-known English torpedo craft builders, and the last of the six, the *Niji*, is shown in the frontispiece, steaming at sea. These six vessels are practically uniform in construction, and on trial gave very similar and highly successful results. Their dimensions are:

JAPANESE TORPEDO BOAT DESTROYER NIJI—311 TONS, 31 + KNOTS—STEAMING AT REDUCED SPEED.

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Length, 220 ft. 3 in.; beam, 20 ft. 6 in.; draft, 5 ft.; displacement, 311 tons. Their armament consists of one 12-pounder and five 6-pounder rapid firers, and two 18-in. torpedo tubes, with six automobile torpedoes. A coal capacity of 90 tons is provided, which gives a low speed steaming radius of 3,000 nautical miles.

The first of these vessels was begun in January, 1897, and the last completed her acceptance trials in January of this year. They are the largest vessels of this type yet turned out by this builder.

All six of the boats are twin screw, fitted with triple expansion four cylinder engines, having cylinders, H. P. 20 1-2 in. dia., I. P. 31 1-2 in. dia., and two L. P. 34 in. dia., and 18 in. stroke. The engines were designed for 6,000 I. H. P., but could be forced considerably above this without distress. They are balanced on the Yarrow-Schlick-Tweedy system, with the low pressure cylinders at the forward and after ends of each engine, and when running are reported to have produced comparatively little vibration. Three-bladed propellers are used. There are four boilers in each of the boats, two for each engine. A separate funnel is fitted for each boiler, and there are two stokeholds, the two middle boilers being placed back to back. Each boiler is of the Yarrow express water tube type*, with straight tubes, and is of large dimensions, having a capacity of 1,600 horse power. With water and fittings each boiler weighed 18 tons. Coal bunkers are situated at the sides of the vessel. Two fans (horizontal), 6 ft. dia., are fitted in each boat, or one fan to two boilers.

Conditions of trial were a speed of 31 knots, with a load of 35 tons on a three hours' continuous run. The trial of the *Niji* was conducted under the supervision of Rear-Admiral H. Kamimura, Chief of the Japanese Naval Commission, and other high officials of the Japanese Navy. On trial the draft of water to the bottom of the propellers was 7 ft. 10 in. aft and 4 ft. 11 in. forward. Observations taken during the three hours' trial gave the following means: Boiler pressure, 204 lb.; first receiver, 53 lb.; second receiver, 7 lb.; vacuum, 23 3-4 in.; air pressure in stokehold, 3-4 in. to 7-8 in.; revolutions per minute, 388.06, and speed, 31.156 knots.

Of all six boats the fastest on trial was the *Sazanami*, with 31.382 knots, and the slowest the *Inadsuma*, 31.037 knots, truly a remarkable showing. One boat of the group, the *Akebono*, was launched only nine days before the official trial, and had only one preliminary run before the trial took place.

Concurrently with the construction of these destroyers more than a dozen others of lesser size and speed were built at other yards in England, France, and Germany for the Japanese Government.

To supply the demand for efficient deck officers in its service, the North German Lloyd Co. has now under consideration the equipment of a sailing ship as a school ship for youths who intend to enter the service of the company. The intention is to establish a three years' course, in which practical seamanship will be taught by the master and officers, and theoretical instruction will be given by a college graduate.

*An illustrated description of one of these boilers was published in our issue of November, 1899, page 225.

STEAMSHIP LINES OF THE PACIFIC COAST—PRESENT FACILITIES AND PROBABLE FUTURE GROWTH.

BY D. S. KIMBALL.

The Pacific coast, unlike the Atlantic, has but a few good harbors, so that one terminal of all the American steamship lines doing business on the Pacific, either coastwise or foreign, is found at San Francisco, Portland, or one of the Puget Sound ports.

When the rush for the gold fields of California began, transcontinental railways had not been thought of, and the water route by the way of Panama offered the only immediate and easy solution of the transportation problem. A line of steamships was at once put on between New York and San Francisco, and the latter port became the Pacific terminus of the first steamship company running to the coast.

California filled up much more rapidly than any other portion of the coast, and San Francisco, having the only harbor for hundreds of miles in either direction, soon became the distributing point for the whole western slope. When the Central Pacific Railroad was built, her position was strengthened still more, and she held undisputed sway as the central point of transportation and distribution until a few years ago, when transcontinental railways across the northern portion of the continent compelled her to share the honors somewhat with the ports farther north. This, of course, did not result in a falling off of San Francisco's trade, but rather in a more independent growth of the northern section of the coast. And while this latter has been rapid, in common with the growth of the whole coast, San Francisco, backed by the great natural resources of California, has kept in the lead as a shipping port, and is still the center of the largest steamer and sailing trade on the coast.

The principal steamship companies operating ocean steamers from San Francisco as a terminus are the Pacific Mail Steamship Co., the Oriental and Occidental Steamship Co., the Oceanic Steamship Co., and the Pacific Coast Steamship Co. Besides, it is the eastern terminal of the Toyo, Kisen Kaisha, a Japanese company with headquarters at Tokio, Japan.

The Pacific Mail Steamship Co. is by far the largest of these corporations, and is the pioneer line of the Pacific. This company operates seventeen steamers, coastwise or foreign, of from 1,500 to 5,000 tons, with a total tonnage of 49,000 tons. The transpacific fleet consists of four ships, the *China, City of Pekin, City of Rio de Janeiro*, and the *Peru*. The first two are of 5,000 tons, and the last of 3,500 tons each. The first three, while not new boats, are well fitted up and very comfortable. The *Peru* is of more recent construction, having been built by the Union Iron Works, about eight years ago.

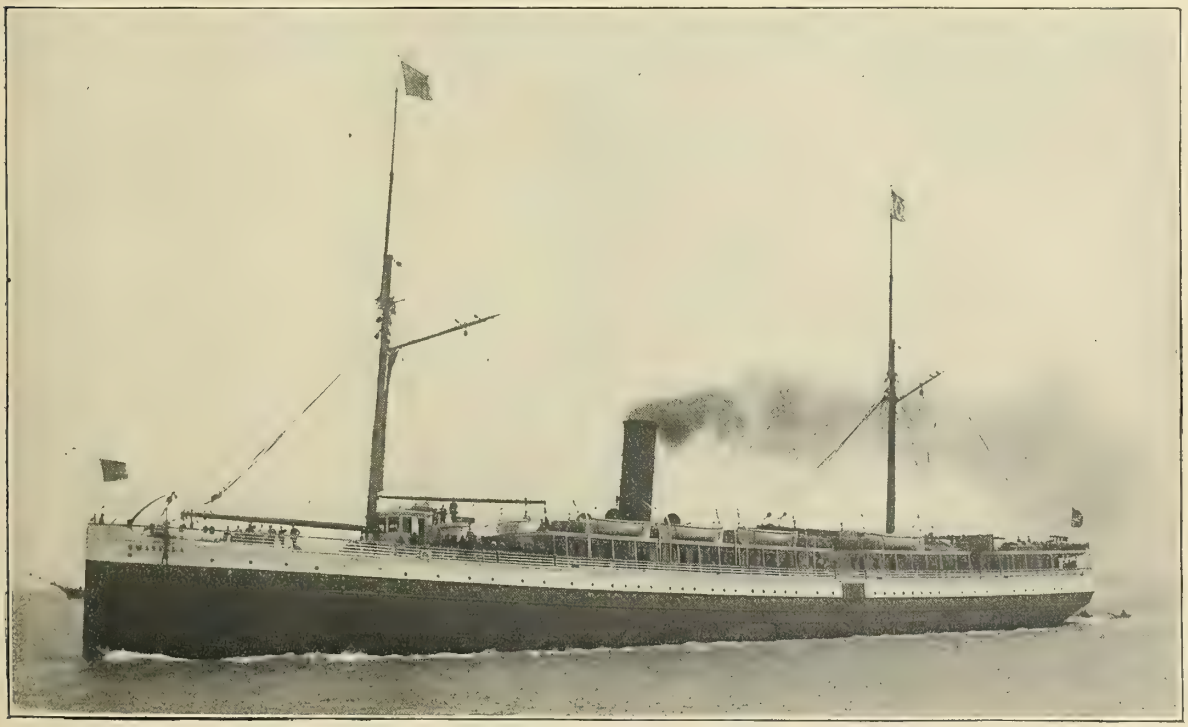
These steamers sail between San Francisco and Hong Kong, touching at Honolulu, Yokohama, Kobe, Nagasaki, and Shanghai, connections being made at the various Asiatic ports with steamers for all places in the Orient, as well as for Europe, via the Suez Canal.

This company has now under construction at the Newport News Shipyard two vessels of about 12,000 tons gross, of these dimensions: Length over all, 575

PACIFIC COAST STEAMSHIP CO.'S S. S. SANTA ROSA—326 FT. LONG, 2,417 GROSS TONS.

ft.; between perpendiculars, 550 ft., and depth, 40 ft. They will have all modern improvements, and will carry a large number of passengers of all classes. They will have quadruple expansion engines, with cylinders, 35 in., 50 in., 70 in., and 100 in. dia., and 66 in. stroke, and are designed to develop about 18,000 collective horse power. It was recently reported also that this company had purchased a steamer of large freight capacity, built abroad.

The coastwise fleet consists of thirteen steamers of from 1,500 to 3,000 tons. They are all of iron and steel, and, like the larger steamers of the company, while not new, are comfortably fitted up. These steamers ply between San Francisco and the principal ports in Mexico



PACIFIC COAST STEAMSHIP CO.'S S. S. UMATILLA—310 FT. LONG, 3,000 GROSS TONS.

and Central America, the southern terminus being Panama, where connections are made with steamers for the west coast of South America, and, by means of the Panama Railroad, with steamers for Europe and the east coast of America.

The Oriental and Occidental Steamship Co. also run a line of four steamers to the Orient on the same route as the Pacific Mail Steamship Co. These steamers, the *Belgic, Coptic, Gaelic* and *Doric*, are not new vessels, having been built several years ago at Harlan and Wolf's yard at Belfast, Ireland. They are, however, luxuriously fitted up, and are of modern construction, having eight water tight bulkheads. The four ships do not differ much one from the other, each being about 430 ft. long, of 4,500 tons, and built along the same lines.

That the Japanese have an eye to the future traffic across the Pacific, is shown by the two steamer lines which they already have running to America. One of these, the Toyo Kisen Kaisha, already mentioned, put on three new steel steamers between San Francisco and the Orient about a year ago. These ships, the *Nippon Maru, America Maru,* and *Hong-Kong Maru*, are sister ships, built in England. They are 440 ft. long, and have a gross tonnage of 6,000 tons. They have twin screws, driven by independent engines, with cylinders 28 in., 46 in., and 75 in. dia., by 48 in. stroke. They are first-class ships in all respects, and were built to conform to Lloyd's rules.

These three steamship lines—the Pacific Mail, Oriental and Occidental, and Toyo Kisen Kaisha—operate on a joint schedule whereby a steamer of some one of the companies sails from San Francisco for the Orient every eight days, all steamers traversing the route as given above, for the Pacific Mail Steamship Co.'s vessels. Considering the distance traveled, this makes good service. All these ships touch at Honolulu both ways.

The Oceanic Steamship Co. operates the only line running regularly to Australia. This company has four steamers of from 3,000 to 3,500 tons, two of which, the *Alameda* and *Mariposa,* are of American build, and while about sixteen years old, are good ships. The *Alameda* lately completed one million miles without a serious mishap, which is certainly a good record. Twice a month steamers of this company sail from San Francisco for Honolulu, and every twenty-eight days for Australia. Next season this company expects to have in commission on this route three new steel ships, now building, of 6,000 tons each.

A comparison of the distances traversed by these Pacific steamers and the time consumed in doing so, with the distances covered and times consumed by the Atlantic liners, may be of interest. Some of the distances on the Pacific seem rather great by comparison.

From San Francisco	to	Honolulu,	2,089	mi'es.
" Honolulu	"	Yokohoma,	3,445	"
" Yokohoma	"	Hong-Kong,	1,450	"
" San Francisco	"	Hong-Kong,	6,381	"
" " "	"	Sydney,	6,514	"
" " "	"	Panama,	3,277	"

The trip from San Francisco to Honolulu is made in about six days, or about the same time consumed by the Atlantic liners in going from New York to Liverpool, a distance of about 3,100 miles.

The total number of regular passenger steamers running out of San Francisco to foreign ports at the beginning of the year 1899 was twenty-eight, with a total tonnage of 98,000. Besides which there is a great freight traffic to all parts of the world, the number of steamships arriving from foreign and Atlantic ports during the year 1898 being 330, with a net tonnage of 592,865 tons. The total number of sailing vessels arriving from foreign and Atlantic ports during the same was 494, with a total tonnage of 530,092 tons.

A steamship company recently organized to engage in Hawaiian trade has now under construction in this country four large vessels of these dimensions: Length over all, 430 ft.; beam, 50 ft.; depth, 34 ft. They will be single screw vessels, with engines of about 2,500 I. H. P., and carrying 8,250 tons dead weight, will have a sea speed of about 10 knots.

San Francisco is also the center of a large coast trade. As yet few railroads connect coast ports, so that a great part of the trade is by steamer, and many companies are engaged in it. By far the largest is the Pacific Coast Steamship Co., which operates twenty passenger steamers, ranging in size from 300 to 3,000 tons, with a total tonnage of 32,000 tons. This company runs steamers to all coast ports from Alaska to Mexico.

The passenger trade between Portland, Ore., and San Francisco by steamer is controlled by the Oregon Railway and Navigation Co., which operates steamers of about 3,000 tons between these ports.

There are also many small companies engaged in coastwise trade, much of which is carried on in steam schooners, peculiarly adapted to the requirements of the traffic, a great deal of which is in lumber.

San Francisco's greatest rivals in the ocean trade will no doubt be the ports on Puget Sound. This beautiful inland sea is one great harbor in itself, having an area of nearly 2,000 square miles, broken up into a maze of bays and inlets, and offering the finest facilities possible for navigation by steamer. There is an abundant depth of water, so that the size of vessels trading to these ports will not be limited by harbor obstructions. Puget Sound is backed by a fine farming country, and already three trans-continental railways have terminals on its shores. Its ports will surely be strong competitors in the race for the commerce of the Orient.

The principal shipping points on the Sound are Seattle and Tacoma. From the latter the Northern Pacific Steamship Co. operates, in connection with the Northern Pacific Railroad, a line of four steamers of from 2,600 to 5,300 tons to the Orient They run as far as Hong-Kong, stopping at Victoria, B. C.; Yokohama, and Kobe.

The same company have lately put in operation a line of three steamers from Portland, Ore., to the same Oriental ports. None of these ships are new, having seen service in other waters; one, the *Arizona,** was the original Atlantic greyhound. A number of the vessels of this company are now doing transport service to the Philippine Islands.

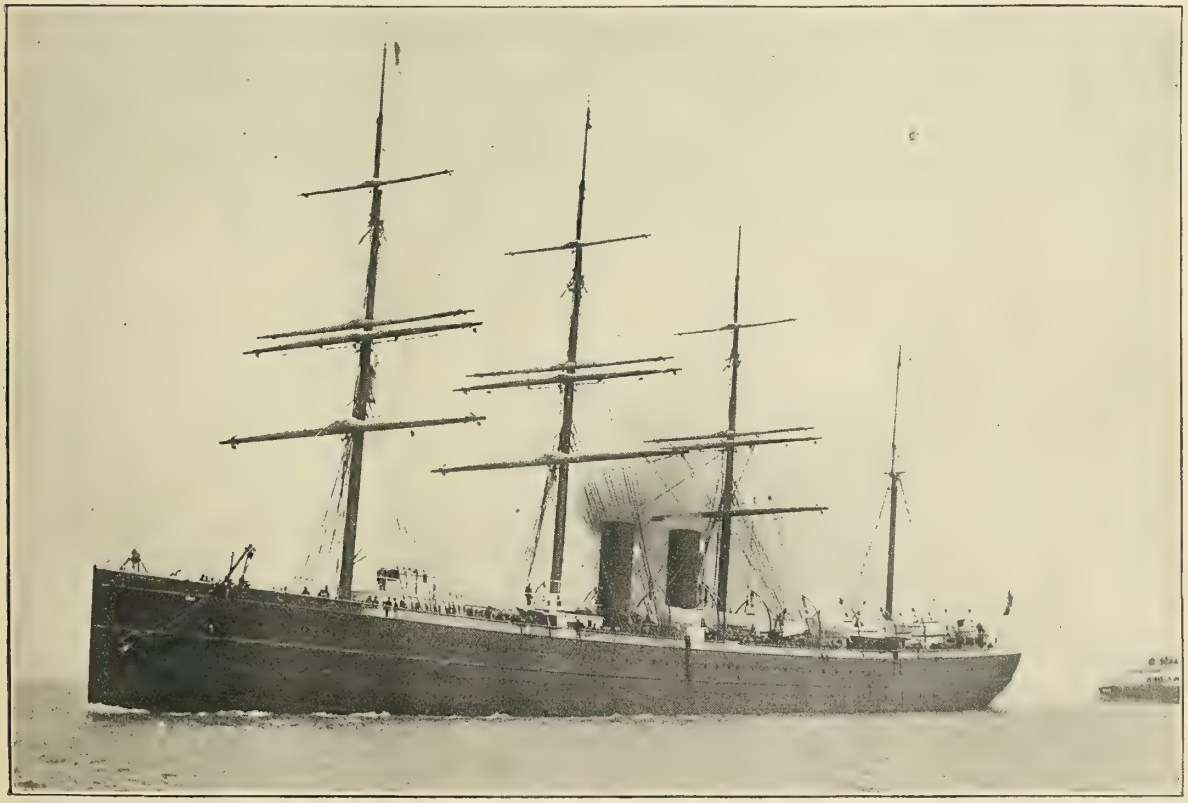
Seattle is the American terminus of the other Japanese line before mentioned. This is the Nippon Yusen Kaisha (Japanese Mail Steamship Co.), which runs in connection with the Great Northern Railroad. At pres-

*An extensive description of this vessel illustrated by photographs was published in our issue of September, 1898.

OCCIDENTAL & ORIENTAL STEAMSHIP CO.'S S. S. COPTIC—430 FT. LONG, 4350 GROSS TONS.

ent three steamers of from 3,200 to 4,700 tons are employed sailing monthly only from Seattle. These steamers are of the combination cargo and passenger type, having accommodation for only a few first class passengers. It is the intention of the Nippon Yusen Kaisha to replace them with new and first-class ships in the near future. Incidentally it may be of interest to note that this company is one of the largest steamship companies in the world, operating altogether a fleet of 70 ocean steamships, varying in tonnage from 3,000 to 7,000 tons and having a total tonnage of 200,000 tons. The company also owns a large fleet of small coast steamers, and has headquarters in Tokio, Japan.

A new steamship line from Seattle to the Orient is projected by J. J. Hill, president of the Great Northern Railway. According to the announced plan of the promoters, the vessels for this service will be of enormous carrying capacity, with low power, so that bulk cargoes,



PACIFIC MAIL STEAMSHIP CO.'S. S. S. PEKING—427 FT. LONG, 5,000 GROSS TONS.

chiefly of grain, can be delivered at Asiatic ports at a minimum of cost.

A large foreign trade is being built up at the Sound ports, the greater part of which is in lumber, the chief article of export of Washington. While some steamers are used in this trade, by far the greater part is carried on in sailing vessels. But at the principal ports, as Seattle and Tacoma, there is a considerable steamship trade. Large quantities of flour and grain are shipped to European and Oriental ports. Many such cargoes are taken out in steamers, nearly all of which are, unfortunately, of foreign build. The import trade from China and Japan by steamer is already very large, consisting mainly of tea, silk and rice, but these commodities do not, of course, furnish cargo to fill all the large vessels on their return trips. An effort is being made to develop a trade in minerals, and now there are some shipments of ore from the Orient as return cargoes. A small steamer trade has lately been established with Honolulu.

The steamer coasting trade from Puget Sound ports is large, and growing rapidly. The coal mines of Washington produce 2,000,000 tons annually. About one third of this is shipped—a large proportion in steam vessels—to different coast ports, particularly those of California. The recent mining developments in Alaska have also resulted in a great increase of the tonnage in that trade. Now, several regular steamship lines are running to Alaskan ports from Seattle or Tacoma, as well as from Portland and San Francisco.

During last summer no fewer than sixteen steamers of from 1,000 to 2,500 tons were making regular trips to Alaska, starting from or touching at Seattle. The passenger end of the traffic is quite considerable. Whether or not this trade will be permanent depends upon the future development of mining in the Klondike region, at Cape Nome, and at other points. The lumber trade is handled almost entirely by sailing ships, as far as coast trade is concerned, although farther down the coast small steamers are used very successfully.

The local trade in Puget Sound will always be carried on to a large extent by steamers. Perhaps no other section of country in the world has such a water privilege as the country surrounding the Sound. From the sea to its headquarters, a distance of 200 miles, there is neither shoal, reef or hidden danger to be found; and while only 200 miles long, its shore line is 1,600 miles in length. This gives some idea of its irregular form, and all these land-locked waters are navigable. Communication by steamer will always be much quicker, easier and cheaper, between most points, and the waters even now are full of small craft. The total number of steamboat lines entering Seattle in 1899 was 33. Many of these, of course, were small lines, and many lines consisted of one steamer only. The local inspectors at Seattle examined 358 steamers in 1898, a considerable fleet for a new country. The conditions are ideal for steamboating, as no violent storms prevail, shipwrecks from natural causes are unknown, and many fast steamers are to be found here, as it is possible to reduce the beam to a minimum on these peaceful waters. A trip from Seattle to Tacoma on the well named *Flyer* is really a pleasant experience. An abundance of wood and coal is at hand and seems to complete the list of requirements for good steamboating.

C RAILWAY S. S. EMPRESS OF JAPAN—455 FT. LONG, 5,900 GROSS TONS.

Crossing over into British Columbia similar conditions are found to prevail. Most of the coast and local traffic is done by steamer, while the Canadian Pacific Railroad has the finest line of steamships sailing from the Pacific coast to the Orient. These steamships, *Empress of India, Empress of Japan,* and *Empress of China,* are 458 ft. long, 6,000 tons gross tonnage, and can steam 18 miles an hour. They have twin screws, driven by independent engines of 5,000 horse power each, and are first-class ships. They were built in England in 1891.

The same company also operates a line of three steamships of 3,500 tons to Australia and New Zealand, touching at Honolulu and the Fiji Islands. The Amer-

NIPPÓN YUSEN KAISHA (JAPAN MAIL STEAMSHIP CO.) S. S. TOSA MARU—445 FT. LONG, 5,794 GROSS TONS.

ican terminus is Vancouver, B. C., which is also the western terminus of the Canadian Pacific Railroad.

The outlook for marine engineering on the Pacific is most encouraging. Up to the present time a rather inferior class of ship has been in use, on the whole, and these waters have been used a good deal as a dumping ground for ships that have outgrown their usefulness elsewhere. But the demand is rapidly growing for new and fast ships, and the recent developments in the far east will soon make such vessels an absolute necessity. There is sure to be a great trade across the Pacific before many years, and, while it may not be possible, financially, to operate vessels over such a great distance with the speed of the Atlantic liners, a great improvement over those now in use must soon be made. The distance from Liverpool to Hong Kong via San

OCEANIC STEAMSHIP CO.'S S. S MARIPOSA—320 FT. LONG, 3,150 GROSS TONS.

Francisco is about 14,000 miles, or a little more than half way round the globe. At present thirty-nine days are required for a continuous trip by this route. Twenty-eight days are consumed in the trans-Pacific portion of the journey, considerable time being lost in stops at intermediate ports. The Canadian Pacific steamers do better in point of time, the *Empress of Japan* having made the run from Vancouver to Hong Kong in 17 1-2 days including stops at the regular way ports. This would make the total time of a continuous trip from Liverpool to Hong Kong about 29 days. The run from Vancouver to Yokahama was made in 10 1-2 days, and the distance is 4,500 miles.

The Pacific route from Europe to China is more direct than the one by the way of the Suez Canal, and good service on the Pacific would make it the quickest and most desirable way.

A great many of the coasting steamers have been built at the different yards on the Pacific coast. As yet few large ocean liners have been constructed, although some of the yards have facilities for building large vessels, one, the Union Iron Works, being too well known to need further comment. There is no doubt but that as the demand for larger and better vessels increases, the facilities for constructing such vessels on the coast will keep step with this progress. All the coast yards are at present handicapped by having to bring their iron and coal from a distance. Iron mines have been found and worked to a small extent. Anthracite coal has been located, but not in any quantity. The country, however, is still in a measure unexplored, and the finding and developing of good iron mines would give steel shipbuilding and marine engineering a great impetus. The greater part of the small coasting steamers are, of course, now constructed of wood, the forests of Washington and Oregon furnishing an unlimited supply of the finest shipbuilding timber to be found anywhere the world over.

NOTES ON SHEATHING U S. NAVAL ACADEMY PRACTICE SHIP CHESAPEAKE.*

BY NAVAL CONSTRUCTOR LLOYD BANKSON, U. S. N.

The sheathing of steel vessels with wood being rather a new subject in this country, from a practical point of view, it is proposed to describe the process of sheathing the *Chesapeake*,[1] the practice ship for the U. S. Naval Academy, built by the Bath Iron Works, of Bath, Maine, from designs furnished by the Bureau of Construction and Repair.

The plans were described in the preceding volume of the transactions of this Society. The ship was launched June 20, 1899, the keel having been laid August 2, 1898.

The specifications for sheathing were, briefly, as follows:

"The wood keel to be of East India teak; to be well secured to the keel plate with brass screw bolts 1 3-8 in. dia.; the false keel to be of white oak 3 in. thick and in lengths not exceeding 12 ft., and fastened to the main keel with composition spikes.

"The planking to extend from the keel to about 26 in. above the water-line amidships, to sheer up 15 in. forward and 12 in. aft. To be of Georgia pine throughout, the upper edge to be covered by an angle 3 in. by 3 in. by 7 lb. per foot. Planking to be worked in one thickness of 4 in. The two top strakes and the planking near the stem and stern-post to be reduced in thickness from 4 in. to 3 1-2 in.

"The garboards to be cross bolted through the top of the keel with 3-4 in. copper bolts. The plank on the bottom to be about 9 in. wide amidships and on the sides about 8 in., tapering forward and aft as may be necessary to make fair work.

"The plank to be fastened with 3-4 in. naval brass screw bolts screwed through the plating between the frames, and to have brass nuts on the inside on iron washers."

The foregoing were the principal requirements in regard to planking and fastening. Several important points came up as soon as the work began, the principal one was in regard to marking off and boring the holes in the planks for the bolts. It was found that most of the planking had to be steamed in order to make a good job in bending it to fit the plating. In doing this it was decided that it was not practicable to mark the holes on the plank from the inside of the ship and then take the plank down again to bore the holes square with the inside surface of the planking. (According to the specifications the holes were required to be drilled in the plating first.)

The work was done as follows: The holes were bored through the planking from the outside after it was secured in place, Fig. 1. After carefully boring the holes from the outside slightly smaller than the diameter of the bolt, the drilling and tapping of the bottom and side plating was done through the holes in the planking, and finally the outer ends of the holes in the planking were counterbored with a plug auger to take the heads of the bolts.

The drilling and tapping of the plates was done both by hand and by pneumatic power. The bolts were fitted in place as follows: A hemp grommet being first put under the head of each bolt with a proper amount of red-lead putty, the bolt was then screwed into the bottom plating through the wood planking and well hove up until the putty was squeezed out around the head of the bolt. A special gang followed the work from the inside of the ship and fitted the washers and nuts. The wrenches used were about one foot long, and in two or three cases the bolts were twisted off. It is thought that a wrench about 8 in. long should be used for 3-4 in. bolts. Various means were tried for heaving up on the bolts from the outside—hand ratchets, hand braces and pneumatic braces. The pneumatic tool was rapid and seemed to do its work well. It was found on examination that with very few exceptions the bolts were square with the inside surface of the plates.

Before fitting the plank in place against the steel plating the hull was carefully tested for water-tightness and all leaks stopped. The skin plating having been originally pickled, it was carefully cleaned and a thick coat of a mixture of white and red lead put on the plating, as well as on the faying surfaces, when each plank was fitted in place. The outside plating was

*Read at the seventh general meet'ng of the Society of Naval Architects and Marine Engineers, held in New York.

[1]For a complete description of this vessel, see MARINE ENGINEERING, Vol. IV, page 168.—Ed. M. E.

fitted in the usual manner with inside and outside strakes. The garboard strakes and sheer strakes were of 17 1-2 lb. plating and the balance 15 lb. plating.

The method of holding the plank in place is shown in. Fig. 1. Great care was taken to have the planking beveled so as to leave a good 1-4 in. seam for caulking in order to avoid the use of the reeming iron. The butts of the planking were specified to fall between the frames, and nearly all were butted as specified. The fastening was well done and the quality of the bolts good. Table I shows the results of tests made as the work progressed.

The specifications required that the bolts were to be made of naval brass, composed of 62 parts of best selected copper, 37 parts of Silesian zinc, and 1 part of tin. The brass bolts to be capable of being bent cold to an angle of 40 deg., when screwed, without cracking or fracture, and to have a tensile strength of 42,500 lb. to the sq. in. The mean of the means of 21 test pieces gave an average tensile strength of 47,204 lb. per sq. in.

Test pieces 1, 2 and 3 (Table I) show the result of using ordinary casting copper and green sand moulds. All other test pieces and all bolts used on the *Chesapeake* were made of tin, Lake copper, and American zinc, and cast in iron moulds. The results may be considered good.

Fig. 2 shows photograph taken of various blank and finished bolts as the work progressed. Exhibit *H*, Fig. 2, shows a finished 1 3-8 in. keel bolt bent with a 14 lb. sledge, the bolt being held firmly in an 8 in. timber and struck on the head. Not a mark or crack showed on the finished surface of the bolt. Exhibit *C* shows a rough blank 3-4 in. bolt taken at random and bent. *D* and *E* are two finished 3-4 in. bolts taken at random and bent; *D* cracked and *E* broke off completely. No. 18 (see Table I) was pulled in a testing machine and broke squarely with a clean fracture. Exhibit *B* represents one of the blank nuts drifted with a pin until it cracked. *A* represents the original size of the blank.

The specifications called for the bolt heads to be covered with Portland cement in the countersink to insure water-tightness. This was done. After the bolts were hove up in place, and the washers and nuts put on and properly hove up, the points of the bolts were center-punched in three places at the top of each nut by special men, to prevent the accidental turning of the nuts and to show that they had been hove up by the proper persons.

The specifications required the caulking to be done in a very careful manner, in order not to strain the fastenings, and the use of the reeming iron was forbidden The seam required was to be between 1-4 in. and 5-16 in. for a 4 in. plank, and other thicknesses in proportion.

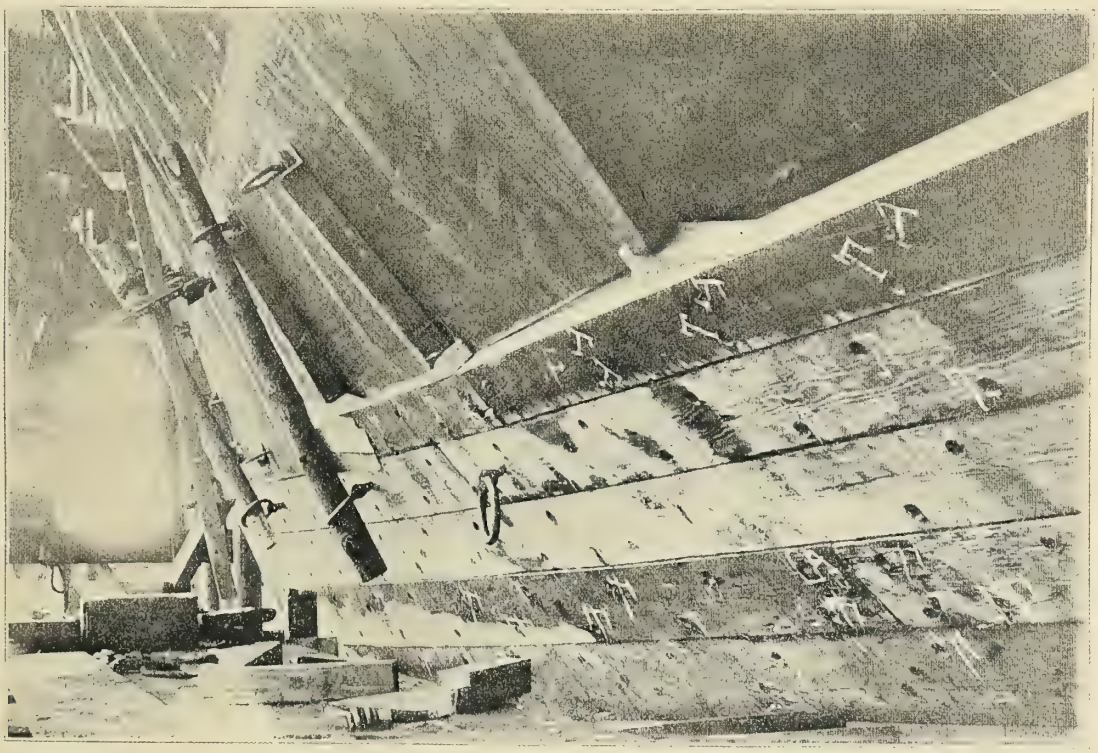


FIG. 1.—METHOD OF HOLDING PLANKING IN PLACE.

Ten threads were required in each seam, and they were driven as follows:—Four threads of oakum were driven into the seams by hand mallet and iron, and these threads were then forced home with horsing-iron and beetle. The first four threads were then followed by three additional threads, driven by hand mallet and iron and then horsed against the first four with iron and beetle.

The seams were then filled up with three threads and properly horsed as before. The outside surface of the oakum, after horsing the seams and dubbing the planking, was about 3-8 in. beyond the surface of the plank. The seams were then payed with hot pitch put on with a mop. A mixture, by weight, of 63.57 per cent. of

white lead, 32.10 per cent. of dry lead, and 4.32 per cent. of linseed oil, was used to fill up the interstices between the inside surface of the planking and the outside surface of the steel hull.

Holes were bored at intervals of about 8 ft. in the center of each plank, and the mixture forced in by about 50 lb. of putty, the smaller size holding about 10 lb.

The amount of putty injected is shown on the list of weights. A comparatively small quantity was required, except in a few places, the planking having been fitted quite snugly to the steel plating. The injected putty

TABLE I.—TESTS OF NAVAL BRASS FOR SHEATHING BOLTS—U. S. S. CHESAPEAKE.

No.	Date of test	Diam. of test piece.	Elastic limit per sq. inch.	Ultimate tensile strength per sq in.	Elongation.	Reduction of area.	Fracture.	Remarks.
1	.....	1.″025	.....	27,593	in 8″	7.8%	Not homogeneous.	Cast in green sand moulds.
2	.....	1.″025	.....	26,535	in 8″	6.25		Ordinary casting copper used.
3	.....	1.″025	.....	22,345	in 8″	3.9		
	Means.....	.....	.....	25,491	.....	5.98		
4	Oct. 25, 1898	1″	.....	46,626	in 2″	21.87	Fine and homogen's	Cast in iron moulds.
5		1″	.....	51,190	in 2″	25.00	Do	Allowance made for cavities.
6		1″	.....	46,301	in 2″	18.75	Two small cavities	
7		⅜″	.....	45,766	in 2″	14.06	Not quite homogen's	
	Means.....	.....	.....	47,471	.....	19.92	21.57	
8	Dec. 13, 1898.	1″	.....	45,651	in 3″	19.8	Two cavities.....	Allowance made for cavities.
9		1″	.....	45,836	in 3″	27.1	Slightly porous	Cast in iron moulds.
	Means.....	.....	.....	45,743	.....	23.45	33	
10	.....	1″	.....	42,585	in 6″	13.54	Cavity.....	Allowance made for cavity.
11	.....	1″	.....	42,842	in 6″	15.63	Cavity.....	Cast in iron moulds.
	Means.....	.....	.....	42,713	.....	14.58	23.44	
12	Jan 7, 1899	7/8″	.....	54,049	in 2″	37.5	Normal	Allowance made for cavities.
13		7/8″	.....	48,827	in 2″	37.5	Slightly porous	Cast in iron moulds.
14		7/8″	.....	50,203	in 2″	28.1	Normal.....	Rapid feed used in testing.
15		7/8″	.....	49,409	in 2″	28.1	Cavity.....	
	Means.....	.....	.....	50,622	.....	32.8	26.5	
16	Apl. 12, 1899.	¾″	.....	55,268	in 2″	27.0	Normal	Cast in iron moulds.
17		¾″	.....	56,305	in 2″	37.0	Normal	Slow feed used in testing machine.
	Means.....	.....	.....	55,786	.....	32.0	30	
18	Apl. 26, 1899.	½″	.....	46,627	.....	.....	Normal.....	Slow feed used. ¾″ bolt and nut. Bolt cast in iron mould.
19	May 4, 1899	½″	.....	45,568	in 2″	31.25	Normal.....	Cast in iron moulds.
20		½″	.....	43,682	in 2″	34.39	Normal.....	Slow feed used in testing.
21		½″	.....	45,848	in 2″	43.75	Normal.....	
	Means.....	.....	.....	45,033	.....	36.46	34	
22	May 17, 1899.	½″	20,376	46,255	in 2″	25		
23		½″	16,811	41,773	in 2″	21.9	23.4	
24		½″	16,811	42,893	in 2″	21.9	23.4	
	Means.....	.....	17,999	43,640	.....	22.9	23.4	
	Mean of means, 4 to 24, both inclusive.....		17,999	47,204	.....	26.02	27.42	

pumps under a pressure of about 10 lb. to the sq. in., the pressure being regulated by means of spring relief valves on the pumps. These pumps were tested at intervals to avoid putting an excessive pressure on the planking from the inside. Two sizes of pumps were used for injecting the mixture, the larger size holding was confined to a series of longitudinal sections in the following manner: Each third strake of planking, commencing with the top of the garboard strake, was lightly chinked with a thread of oakum before the next strake was put in place.

The planking began with the keel and garboard

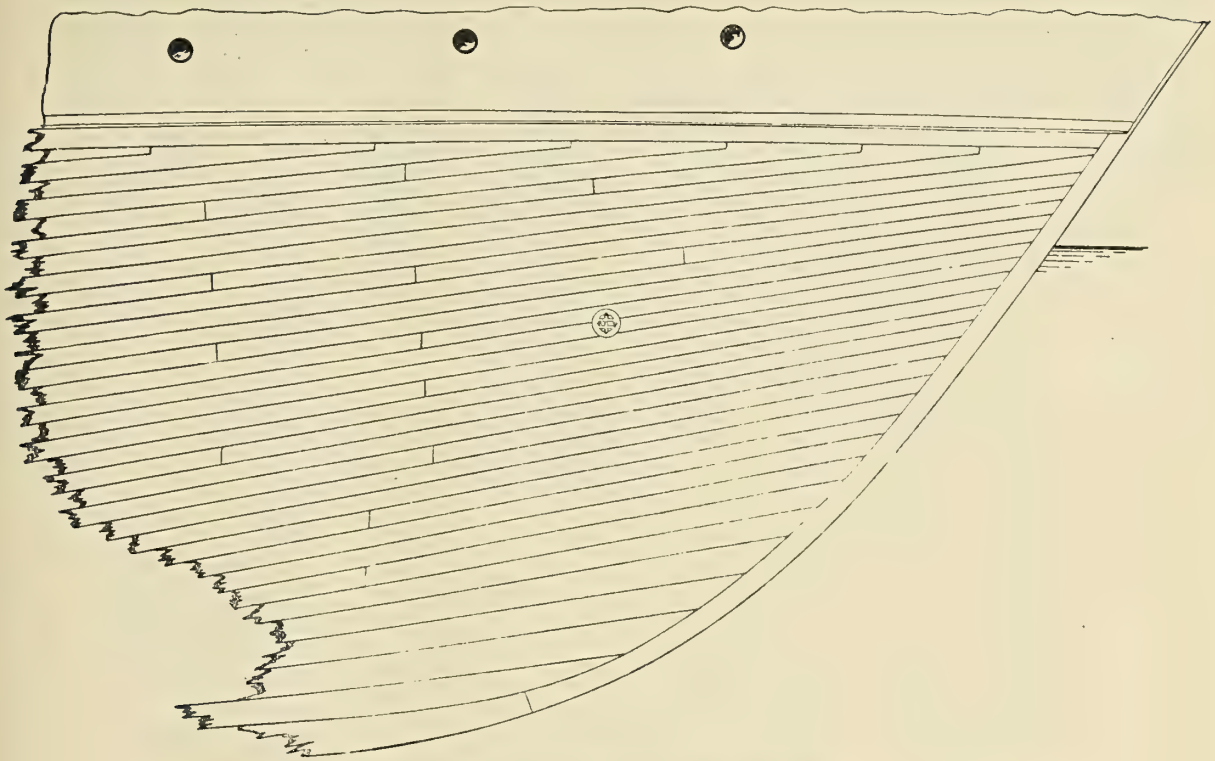


FIG. 3.—VIEW OF PLANKING AT FORWARD END.

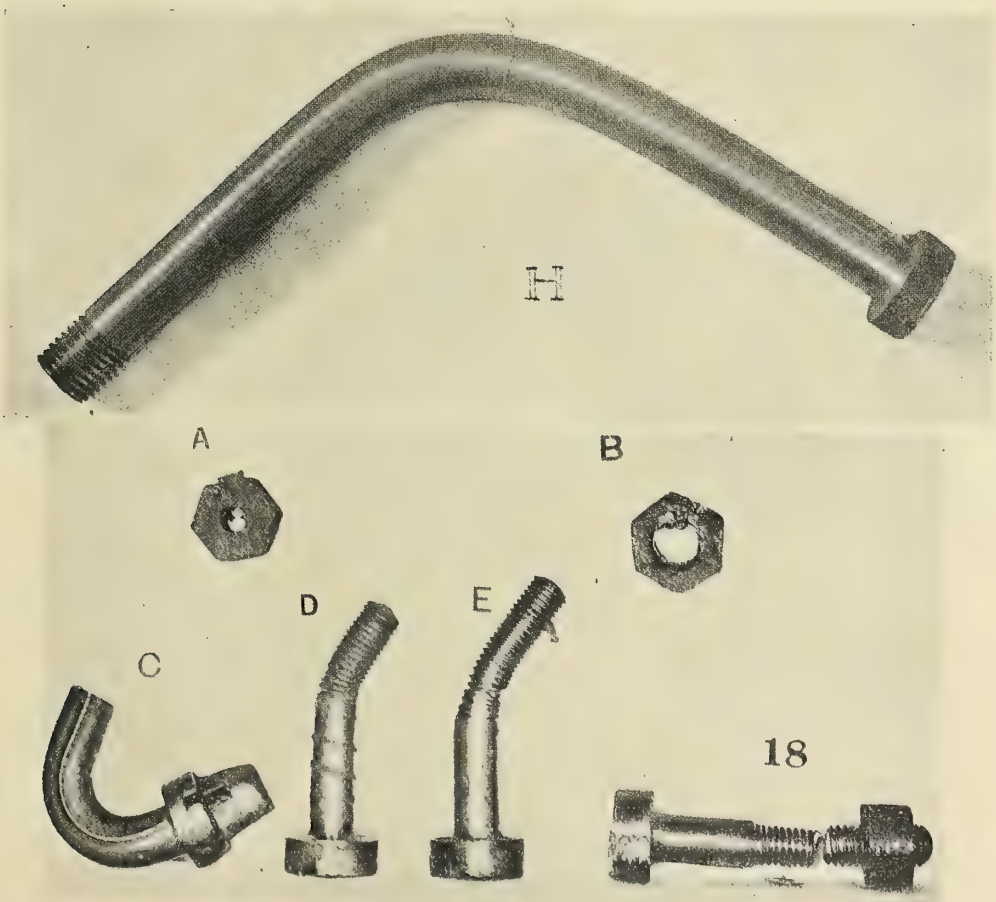


FIG. 2.—PHYSICAL TESTS OF BOLTS USED IN SHEATHING.

strakes, and was worked upwards until completed, the top strake, however, being fitted in place after the garboards. Fig. 3 shows a view of the planking forward.

The following practical points were noted during the sheathing of the *Chesapeake*. Difficulty in making a good water-tight job between the bronze stem and stern-post casting and the outside plating by caulking. The riveting of this work should be arranged in such a manner that it should be tight without depending on the caulking of the outside seams.

It is thought that the greatest trouble may be looked for around the stern-post, and it will be well to examine this part of all sheathed vessels as often as good judgment prompts until more experience is had with sheathed vessels, although the injection of putty under pressure should complete the work of making the sheathing perfectly water-tight.

It was found in several cases that the bolts fetched up against the vertical longitudinal bulkheads in inaccessible places before the heads were up against the planking. These few bolts leaked, but the trouble can be easily remedied by backing out the bolts (which have no nuts on them), shortening them, and heaving them up hard against the planking from the outside when in dry-dock.

In designing a vessel to be sheathed great care should be taken to make the lines around the stern as easy as possible to allow the planking to be bent with as little work as possible, otherwise the planking is strained or else it has to be shaped from large pieces at considerable expense. Oak was substituted in one or two cases under the stern of the *Chesapeake*, as it can be bent more easily when steamed than yellow pine, which is not affected to a marked degree by steaming.

The stern-post, rudder-frame, and stem, up to about four feet above the water-line, were made of Hyde bronze. Table II gives the results of tests of this material taken from the different castings.

TABLE II—HYDE MANGANESE BRONZE CASTINGS FOR U. S. S. CHESAPEAKE.

No.	Date.	Diam. of test piece.	Ultimate tensile strength per sq. in.	Elastic limit per sq. in.	Reduction of area.	Elongation.	Fracture.	Remarks.
25	Apl. 12, 1899.	1″	60,103	.....	28%	25%	Slight flaw in center	From rudder frame casting.
26		1″	60,281	.....	34	in 2″ 34	Perfect.....	Slow feed used in testing.
27		1″	58,409	....	23	in 2″ 28	Slight flaw in center	
	Means.....	.....	59,598	.....	28.3	 29		
28	Apl 26, 1899.	1″	59,728	.....	34	in 2″ 34	Perfect.....	From stem casting.
29		1″	57,213	28,007	34	in 2″ 34	Perfect.....	Slow feed used in testing.
	Means.....	.....	58,470	28,007	34	 34		
30	Apl. 26, 1899.	1″	61,153	29,287	34	in 2″ 34	Perfect.....	Stern post casting.
31		1″	60,795	26,738	23.4	in 2″ 23.4	Perfect.....	Slow feed used in testing.
	Means.....	.....	60,974	28,012	28.7	..... 28.7		
32	June 10, 1899.	1″	54,908	21,645	34	in 2″ 34	Perfect.....	Extension of stern post.
33		1″	53,689	21,034	34	in 2″ 34	Perfect.....	Slow feed used in testing.
	Means.....	.....	54,298	21,339	34	 34		

WEIGHTS OF MATERIALS USED FOR SHEATHING THE CHESAPEAKE.

152 naval brass 1 3-8 in. keel bolts, b ass nuts and iron washers		1,836 lb.
972 naval brass 7-8 in. plank bolts, brass nuts and iron washers		1,895
8,103 naval brass 3-4 in. plank bolts, brass nuts and iron washers		7,874
12 naval brass 3-4 in. plank bolts		17
5 copper bolts, blunt, 1 1-4 in		38
37 copper bolts, blunt, 7-8 in		170
113 composition spikes, 1-2 in. square, 7 in. long		53
		11,883
Outside planking, yellow pine	123,403 lb.	
Teak keel	21,107	
False keel	2,854	
Oakum and pitch	6,391	
Putty pumped between plating and planking	6,857	
Hemp grommets for brass bolts	65	
Putty for grommets	500	
Sand and cement for plugging bolt holes	1,136	
		162,313
		174,196 lb.

RECAPITULATION.

Metal fastening	11,883 lb.	6.82 per cent.
Yellow pine plank	123,403	70.84
Teak keel	21,107	12.13
False keel	2,854	1.63
Oakum and pitch	6,391	3.67
Putty and grommets for bolts	7,422	4.26
Cement for plugging bolt holes	1.136	.65
77.77 tons = 174,196 lb.		100.00 per cent

Approximate area of sheathed surface (omitting area of flat keel), 7,583 sq. ft.

Weight of sheathing materials per sq. ft. (omitting teak keel, oak false keel, also fastenings of keel and false keel), 23 lb.

The weight of the boundary angle at top of wood sheathing is not included in any of these tables or calculations. This angle is 3 in. by 3 in. by 7 lb. and weighs 2,345 lb.

ENGINEERING IN THE UNITED STATES NAVY—ITS PERSONNEL AND MATÉRIEL.—II.*

BY ENGINEER-IN-CHIEF GEORGE W. MELVILLE, U. S. N.

The most notable of his experiments was the series which gave the complete demonstration of the relation between cylinder condensation and the rate of expansion. Until these experiments, most engineers believed that the law of Mariotte, that the product of pressure and volume is constant, was strictly applicable to steam as well as to permanent gases, and that a very large ratio of expansion with low pressures of steam would be profitable. Isherwood's experiments on the *Michigan* demonstrated conclusively that under the conditions there obtaining, of a slow-moving engine and a low steam pressure, a ratio of expansion was soon reached beyond which any increase would cause an absolute diminution of economy, instead of an increase thereof, as would have been predicted from a strict adherence to Mariotte's law. Every young engineer knows this thoroughly to-day, and is cautioned about it in his text-books; but so far from its being readily accepted when Isherwood's experiments had demonstrated the true facts, many will remember that he was assailed in the public prints as being guilty either of hopeless ignorance or wilful waste of the Government money.

Mr. Isherwood was not only a splendid experimentalist, but a designer of the first rank, and an executive engineer who has not been surpassed. He was Engineer-in-Chief of the Navy during the whole of the War of the Rebellion, and during that time was responsible for a large number of designs. Here again he was criticised from the academic point of view, and yet the very faults for which he is criticised only appear, on proper analysis, the more praiseworthy as excellent details of sound designing. He was accused of building engines which were inordinately heavy, which accusation he has never denied. To the mere office engineer this was true, but he realized what they did not, that these engines had to go into the hands of men who were largely untrained and unfamiliar with machinery. The ordinary formulæ for design assume reasonably decent handling, and do not provide for the stresses due to ignorance and carelessness. Isherwood knew that the point of first importance was to build engines which would not break down, and, in fact, could not be injured by ignorant and careless handling. The result of this policy was engines very much heavier than would ordinarily be built; but they did not break down, and they carried our ships to victory. To my mind this was the highest proof of his talent as a sound designer. He had the courage to invite criticism from the book engineer in order that he might insure success for the country.

You all know the story of the *Alabama*, and how she and her sister commerce destroyers drove our merchant marine off the ocean. The Navy Department felt it important to get a class of vessels that would be faster than the *Alabama*, or any other vessel likely to be built, so that they could sweep the seas of all these commerce destroyers. A number of designers were concerned in projecting both hulls and engines to accomplish this result, but although the great Ericsson was one of his rivals, Isherwood's ships were the only ones which really accomplished what was intended. The *Wampanoag* was the first of Isherwood's ships to be tried, and she was a magnificent success in every way—really in many ways the greatest success as a steam war vessel that the world has ever known, because she distanced everything that had preceded her so much more than has ever been accomplished before or since. The *Wampanoag* was given a trial lasting 37 1-2 consecutive hours between Sandy Hook and Cape Hatteras, and for the whole run averaged nearly 17 knots per hour. During several 6-hour periods her speed was over 17 knots, and for several single hours she made over 17 1-2. It should be noted also that this was not a smooth weather run, as the trial was ended prematurely owing to a gale, and for some time previous the weather was heavy. The speed made by the *Wampanoag* was at least 4 knots more than that of any other ship—either mercantile or naval—of her period, and, in fact, it remained the record speed for many years. Even the first fast cruisers of modern navies, like the *Esmeralda* and *Naniwa*, while nominally credited with a higher speed, only made it over the measured mile, or for a short spurt, while the *Wampanoag's* record was, as stated, for more than 37 hours. Another of the Isherwood ships, the *Ammomoosic*, was given only a short trial, but showed qualities equal to those of the *Wampanoag*. The best of the rival ships made a speed of about 15 knots for less than an hour, and the other vessels fell below the *Wampanoag* even more than this.

It is not perhaps generally known that in calling the *Wampanoag* an "Isherwood" ship the designation is more inclusive than might be supposed at first glance, for Mr. Isherwood was responsible for those features of the hull design which affect speed. The design of the hull as a whole was worked out by Naval Constructor Delano, an accomplished naval architect, but he simply took the form of hull by Mr. Isherwood and worked out the structural details necessary to carry out his ideas.

It would be supposed that Isherwood"s brilliant achievements would have brought him only gratitude and thanks; but, on the contrary, his vigorous methods had aroused a great many enemies, so that at the end of his second term as Chief of the Bureau of Steam Engineering there was sufficient influence to prevent his reappointment to the office which he had so well filled, and he was banished to the Mare Island Navy Yard; but this only gave him an opportunity for some of his best experimental work, and the famous propeller experiments, which are still a mine of valuable information for designers, were conducted there with the assistance of William R. Eckart, a former engineer of the navy and an honored member of this society.

After these experiments, and until his retirement, Mr. Isherwood conducted many others which have given valuable information to engineers, and it may be well in passing to remark that his reports of experiments are models to which all young engineers can refer with great profit to themselves. The thoroughness with which the apparatus under experiment is described and its dimensions given, the elegance and lucidity of the language, and the admirable arrangement, are all models of what such a report should be, just as Macaulay's style is so justly commended to all young writers.

From a remark which has just been made as to the

*President's address (1899) at New York meeting of American Society of Mechanical Engineers.

qualifications of many of the engineers who came into the navy during the War of the Rebellion, it might perhaps be inferred that there were few men of real ability; but this would be unwarranted, and would be an entire mistake. The total number of engineers was so large that it was utterly impossible to have even a majority of them skilled men; but a number of talented young engineers came into the service, and the profession generally has learned to recognize their ability from the fact that in the years since the close of the war a large proportion of the leaders in mechanical engineering in our country are men who were naval engineers during the war. The first president of this society (Dr. Thurston), as well as the second (Dr. Leavitt), were naval engineers, and so was that other able man, Charles E. Emery, now gone to his long rest. William Everett, who became famous in connection with the laying of the first Atlantic cable, was another, and so was George Westinghouse, whose wonderful achievements, both as an inventor and as the creator of great industrial works, entitle him to be called the Napoleon of industrial engineering. Theodore Cooper, the great bridge engineer, and Lay, the inventor of the automobile torpedo, were naval engineers during the war. We must also call attention in passing to Chief Engineers Alban C. Stimers and Isaac Newton, who brought the original *Monitor* down to Hampton Roads and enabled her to whip the *Merrimac*. But for their ability and indefatigable labors the results would have been very different. We might also recite case after case of gallantry and daring where vessels were saved by the skill of the engineers; where they lost their lives through attention to duty, or where they distinguished themselves specially in other ways, but time will not permit us to dwell upon these features.

During all the period which we have thus far considered, the engineers for the navy had obtained their education outside of naval influence; but in 1866 a class of young men was ordered to the Navy Academy to be trained as engineers in a naval atmosphere. A number of these gentlemen are still in the service, and were chief engineers of our large vessels during the recent war with Spain. In 1871 engineer cadets were appointed for the Naval Academy, the course being for two years only, until in 1874 a class was appointed whose course was to be for four years.

These young men were appointed by competitive examination open to the whole country, and as the course became better known the numbers who came to compete increased, and their attainments became so high that an unusually able class of young men was obtained as cadet engineers. Unfortunately for the service, Congress was seized with one of its periodical fits of retrenchment, and as no patronage was affected by abolishing the cadet engineer system, the separate course for engineers was wiped out in 1882, and for a time engineering education dropped out of the curriculum at the Naval Academy.

It is probably safe to say that the young men graduated from the Naval Academy under the cadet engineering system presented a higher average ability than any equal number of young men from any of our great technical schools; indeed, so great was their ability that the service was unable to retain them, but the country has profited from the training they received by their work in civil life. A number are filling positions as professors of mechanical engineering in our leading colleges; a number are consulting engineers of the highest rank, and several are engaged in the management of our large manufacturing enterprises—one (who is a vice-president of this society) being the general manager of one of the largest electric companies in the world. It is a peculiar pleasure to me to bear tribute to the talents of these young men, because a great many of them have served as my assistants in the Bureau of Steam Engineering, and while I am naturally filled with regret that the navy should lose their services, I also feel proud that my own judgment in estimating their ability should be so thoroughly confirmed by the esteem in which they are held by engineers outside of the navy. I would not have it supposed from my remarks about those who have left the service that they took all the ability with them. Some of the most useful and accomplished officers, graduates and non-graduates, are still in the service, which I trust will be able to retain them.

In this connection, too, it is only right that I should bear testimony to the worth of the men who, at the Naval Academy, trained these young engineers. One of the earliest of the instructors was Dr. Thurston, the first president of this society, whose fame as an educator is world wide; but there were others who, while not so well known, nevertheless did splendid work. Just as I remarked at an earlier point about the work of Mr. Haswell and others as pioneers, so it was with these early instructors in engineering at the Naval Academy, who had practically no text-books, and who were compelled, in the professional part of the instruction, to depend almost entirely on their own experience; further than this, they had nothing to guide them in the way of a curriculum, and they were compelled to establish one tentatively and develop it as experience dictated.

Curiously enough, just about the time when Congress was undoing the splendid engineering work at the Naval Academy, the Navy Department itself was formulating plans for vessels which should be designed along lines so different from those which had preceded that the familiar epithet applied to them—the "new navy"—is entirely appropriate. The labors of the first advisory board made available a mass of information, as a result of which Congress in 1883 authorized the building of the four Roach cruisers, which were the beginning of the new navy. These vessels, I may say in passing, although possessing few features of novelty, as far as marine engineering in general is concerned, were nevertheless a marked change from the old wooden ships which had preceded them, and they rendered very valuable service, and are still, with modernized machinery, very satisfactory and useful vessels.

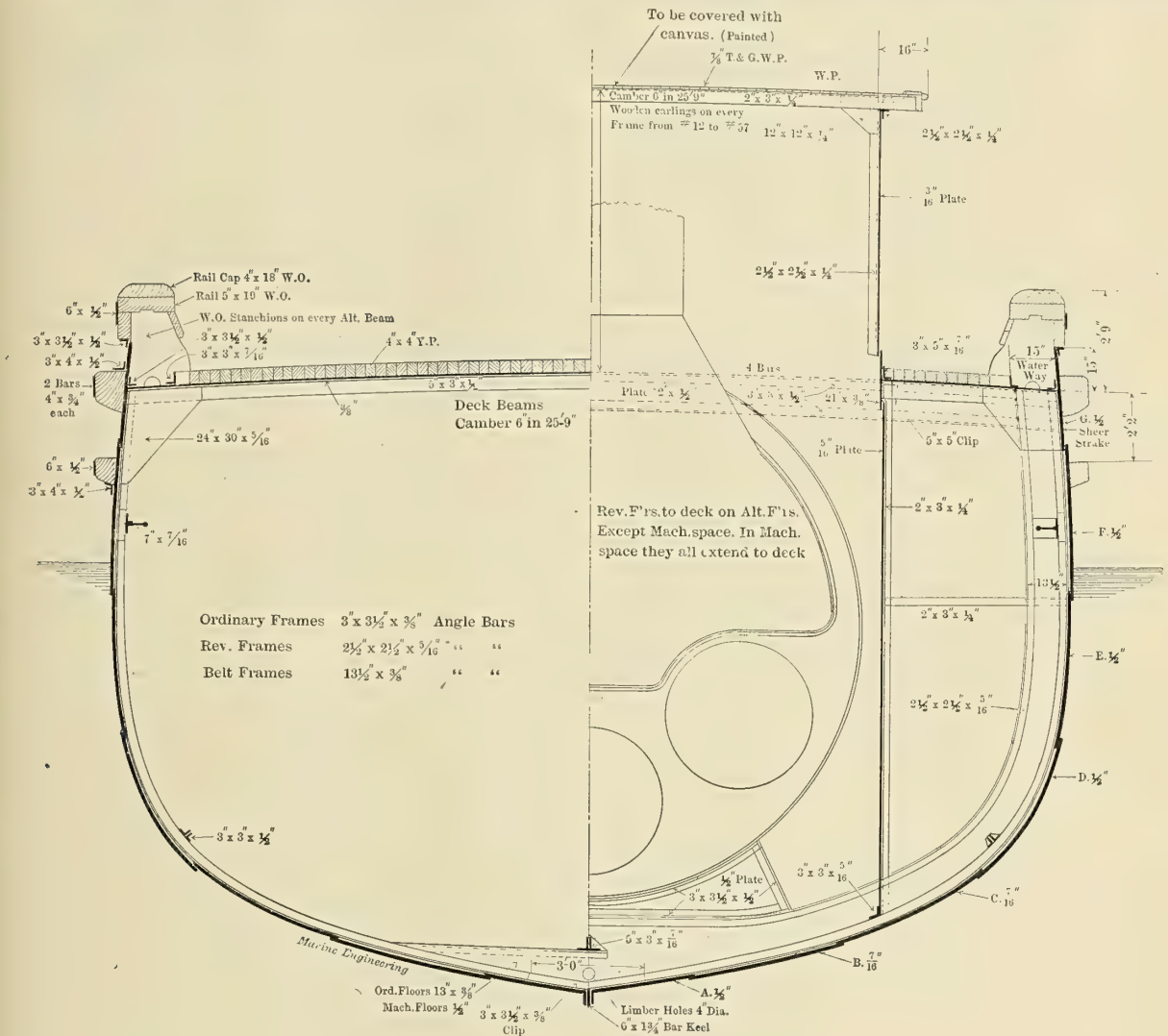
Through an unintentional error in connection with the publication of an extensive description of the new United States floating steel dock for Algiers, La., in our February issue, we omitted to acknowledge our indebtedness to Joseph Beale, Washington, D. C., for most of the data presented and the accompanying drawings. Mr. Beale is the representative in this country of Clark & Stanfield, the leading firm of designers of floating docks of London, England.

NEW STEEL SCREW TRANSFER TUGS FOR THE N. Y., N. H. & H. RAILROAD CO.

Two large, powerful steel screw tow boats for the New York, New Haven and Hartford Railroad Co., to be used as transfer tugs between Oak Point and Jersey City in New York harbor, are now under construction at the yard of the Bath Iron Works, Bath, Me. These vessels are very interesting examples of their type. They are ideal tow boats for inland or harbor work, and their hulls are as small as it is possible to make them and envelop the powerful machinery required.

The principal features of these vessels are: Very large boiler power in relation to the size of engine; airy accommodation for the crew all above deck; large roomy engine and boiler rooms; heavy oak rail for towing purposes throughout the length of the vessel; large water tanks, well arranged for trimming fore and aft and for listing athwartships; first-class arrangements for rapidly handling the vessel and her car floats.

In dimensions these tow boats are as follows: Length over all, 134 ft. 6 in.; load water line, 119 ft. 6 in.; beam, 25 ft. 9 in.; depth, at side, 16 ft. 3 in.; at center, 16 ft. 9 in.; draft, forward, 11 ft.; amidships, 11 ft. 9 in.; aft, 12 ft. 6 in. They have a solid bar keel 6 in. deep and 1 3-4 in. thick, the scarphs being 17 1-2 in. long, well planed and calked. The stem is a wrought iron bar 8 in. deep and 2 in. thick, well rabbeted to receive the shell plating, and scarphed to the keel. The stern frame proper is also an iron bar 6 in. deep and 3 in. thick. It is rabbeted to the keel, bossed for stern tube, and in the tuck it is twisted and forged so that the stern frame, which continues to the extreme aft end of the fantail on counter, is a bar 6 in. wide, varying in thickness from 3 in. to 1 in. The shoe is a very heavy forging welded to the main stern post. It is about 12 in. wide and 5 to 6 in. thick. A balanced rudder of unusual proportions is fitted with a face 9 ft. 6 in. long, of which 2 ft. 6 in. is balanced. The frame is of wrought iron, forged in one piece. The stock is 8 in. dia., and the pintle is 6 in. dia. There are two arms or braces, the space between them being filled in with pine; the whole being covered with steel plating well riveted and tapped to the stock and frame.


To be covered with canvas. (Painted)
Rail Cap 4" x 18" W.O.
Rail 5" x 10" W.O.
W.O. Stanchions on every Alt. Beam
4" x 4" Y.P.
Deck Beams Camber 6" in 25-9"
Rev. F'rs. to deck on Alt. F'rs. Except Mach. space. In Mach. space they all extend to deck
Ordinary Frames 3" x 3½" x ⅜" Angle Bars
Rev. Frames 2½" x 2½" x 5/16" " "
Belt Frames 13½" x ⅜" " "
Water Way
Sheer Strake
Ord. Floors 13" x ⅜"
Mach. Floors ½"
Clip
Limber Holes 4" Dia.
6" x 13/4" Bar Keel
Marine Engineering

CROSS SECTION OF STEEL TUGS FOR N. Y., N. H. & H. RAILROAD CO.

The frames are of angle steel, 3 1-2 in. by 3 in., spaced 23 in. apart throughout the vessel's length. Double or intermediate frames are worked for seven frame spaces forward and four frame spaces aft, in the vicinity of the load water line, to resist crushing by ice. There are belt frames in the vessel located where the deck is cut at the hatches, and where the greatest weights are placed and the greatest stresses are apt to occur. Reverse frames of angle steel, 2 1-2 lb. by 2 1-2 in., are located on every frame, extending to 1 ft. above the bilge and to the deck stringer on alternate frames. Double reverse frames are worked in the machinery spaces. The floors are in one piece on every frame, 13 in. deep at the center line amidship. The main deck beams are 5 in. by 3 in. extra heavy angle bars located on every frame. The shell plating is composed of a heavy flanged garboard strake, a heavy sheer strake projecting 15 in. above the main deck at the side, and four strakes of 1-2 in. bottom, bilge and side plating arranged as usual in "in and out" strakes. The gutter waterway on deck is 15 in. wide, and it is bounded by 3 1-2 in. by 3 in. angle bars. The main deck stringers and deck plating are 3-8 in. thick. The bilge keelson is composed of double angles riveted back to back. The side stringer is a 7 in. extra heavy bulb tee bar, and both bilge and side keelsons are continuous from stem to stern.

The tugs have each six complete watertight transverse bulkheads, composed of 1-4 in. steel plate, well stiffened by angle bars the same size as the frames. Bulkhead No. 5 is the collision bulkhead and the forward bulkhead of the forward tank. Bulkhead No. 12 is the after bulkhead of the forward tank and the forward bulkhead of the steering engine space. Bulkhead No. 18 is the forward bulkhead of the boiler room and wing bunkers and the after bulkhead of the steering engine space. The space between frames 12 and 18 will be used for hawser stowage, lamp room, steering engine and miscellaneous deck gear stowage. A steel flat at the level of the lower deck divides this space vertically. Bulkhead No. 39 is the after boiler room and wing coal bunker bulkhead and the forward engine room bulkhead. Bulkhead No. 55 is the after engine room bulkhead, the stuffing box after peak bulkhead, and the forward bulkhead of the after tank. Bulkhead No. 61 is the after bulkhead of the after tank. The steering gear occupies the space aft of bulkhead No. 61 in the lazarette. The two large tanks extend from the floors up to the main deck. They are divided in the center line of the ship by a steel bulkhead well stiffened, the only communication between the two sides of the ship being through an area of about 1 sq. ft. near the base.

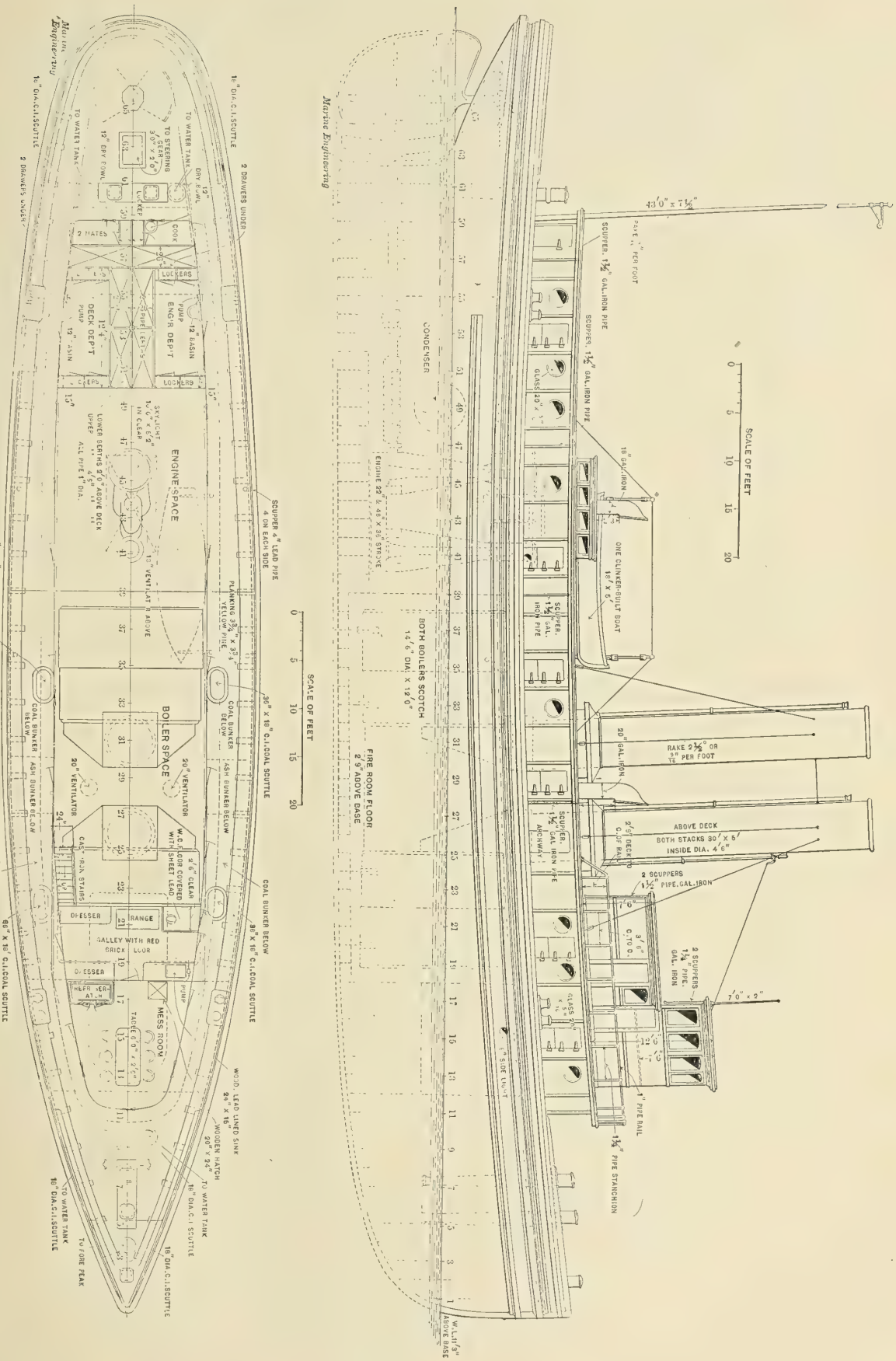
There are no athwartship coal bunkers on these vessels, and the wing bunkers extend from frames 18 to 27, and from frames 30 to 39 on each side. Ash bunkers, or space for stowage of ashes, are located in the wings, midway between the bunkers on each side of the vessel. The floors under the engines are increased in depth, and four continuous fore and aft keelsons are fitted. The two inboard keelsons extend aft under the thrust bed, and the holding down bolts for the engine and thrust bed pass through the reverse angle on top of these intercostal keelsons. The engine and thrust-bed framing is plated over with heavy steel plate, the engine bed being perfectly flat. The shaft tube of each tug is a steel plate tube strapped on the outside and riveted to a boss on the stern frame and to the after peak bulkhead, and two ordinary frames by means of angle bar collars.

The steel deck house is 92 ft. long, and at its widest part 15 ft. 9 in. wide. It is constructed with a vertical steel coaming plate, secured to the steel deck by a 5 in. by 3 in. angle bar. The side plates run vertically and being butted at their edges, the strap placed on the outside, have a panelling effect. These plates are 3-16 in. thick and about 4 ft. wide. The deck house stiffeners are 3 in. by 2 in. angle bars, and the beams are of the same size, a wooden carling being fastened to each one of them. The fore and aft coal bunker bulkheads are composed of 5-16 in. steel plates and amidships this bulkhead is directly connected to the coaming plates of the deck house.

The main deck is planked with 4 in. by 4 in. yellow pine. The top of the deck house is made of 7-8 in. tongued and grooved stock, and this top overhangs the steel house 16 inches. One of the features of the ship is the heavy and well connected oak rail. The stanchions for the rail are of white oak, located on every other deck beam. They are 21 in. by 7 in. at base and 24 in. high. The rail is white oak, 19 in. by 5 in., and the rail cap is of the same material, 18 in. by 4 in. The rail is well secured to 4 in. by 9 in. outside plank and angle bar on top of the shear strake. It is also well secured to the deck stringer, and each stanchion is fastened to the rail and rail cap, being let into the former about 2 inches. A 3 in. by 9 in. oak plank is also secured to the rail and rail stanchions on the inboard side.

Four extra heavy cast iron bitts are located on the top of the rail, one on each quarter. The inboard forward bitts are of white oak, standing fore and aft, and stepped on a platform below the level of the lower deck in the forward tank. The bitts are 16 in. square capped with a brass cap 1 in. thick. A Hyde hand windlass with double gypsy head is directly connected to these bitts. The after bitts are the same as the forward ones except that they stand athwartship just abaft the aft end of the house. They step in the after tank at a height just above the lower deck. A nigger head 24 in. high and 16 in. square of oak is located forward, and capped with a brass cap, just abaft the stem head. Chocks are fitted fore and aft above the rail cap. An upper guard or wearing piece is worked all around the vessel at the height of the main deck. It is 13 in. by 10 in. white oak, faced with two 4 in. by 3-4 in. steel plates. A lower wearing piece is worked from the after quarter to the stem on both sides of the ship. It is 9 in. deep and the width varies so that its face, which is capped with a 6 in. by 1-2 in. plate is in the same vertical line with the upper guard face throughout.

The forward compartment of the deck house is the mess room, which contains a table and six or eight chairs. In it is a large refrigerator and a hatch to the steering engine and hawser space below. Then comes the galley, 14 ft. 6 in. by 7 ft. 6 in., with range, dresser, sinks and the usual fittings and furnishings found in a modern, well arranged kitchen. A water-closet is on the port side. The boiler and engine casings occupy



PLANS OF STEEL TUGS FOR N. Y., N. H. & H. RAILROAD CO., BUILT AND ENGINED BY THE BATH IRON WORKS, BATH, ME.

over 53 ft. in length in the deck house. Aft of the after engine casing bulkhead is a space 12 ft. 6 in. long divided at the centre line by a bulkhead. On the port side are four pipe berths for the oilers and firemen, and on the starboard side are four similar berths for the crew of the boat. These rooms are exactly alike and include four lockers and a wash stand with pump directly connected to water tanks below. Aft of these rooms are two staterooms for cooks and mates, complete and well arranged.

The pilot house on the top of the deck house forward is a lofty structure 12 ft. 6 in. high and 8 ft. wide. It will be neatly finished on the inside with black walnut, hardwood floor, lockers, upholstery, etc. The steering wheel connects by vertical shaft with the valve of the Williamson steering engine down below. There is no hand steering gear on the vessel. Aft of the chart house are two staterooms, each containing two berths and lockers. The forward one is for the Captain and the after one for the Engineer. Full-size windows in the aft end of the chart house are located looking over the adjoining house, which is 5 ft. lower than the chart house. The eye of an observer in the pilot house will be over 26 ft. above the water line when the tugs are in the load condition and trimming evenly. The iron deck house is fitted with double swing steel doors throughout and 20 in. circular air ports. A handrail is worked around the forward part of the top of the deck house. A turret skylight is located over the engine casing, and the deck house top is so arranged that the engines and boilers can be easily taken out of the vessels.

One 18 ft. square stern clinker-built life-boat will be carried by each boat on davits. One 800 lb. stockless anchor and 75 fathoms of 1 in. stud link chain will be carried. These transfer tugs have no spars or sails, as they are designed for inshore work. Each vessel will be fitted with a 43 ft. signal staff located at the after end of the deck house. Small flag poles are located at the after end of the pilot house of one to distinguish it from the other.

The rudders of these vessels, as before mentioned, are unusually large, and the steering gear is unusually powerful. A yoke is attached to the rudder head with double quadrants, thus eliminating slack and doing away with the usual quarter guide sheaves. The rudder area is about 110 sq. ft., and this is made so large because it is not only the rudder of the tug boat, but it must act as the rudder of the float which she will tow on either side of her.

These new tow boats will be well lighted by electricity. There will be 50 16 C. P. incandescent lamps, and the generating set will be a 3 K. W. Riker machine with Case engine. They will be well ventilated, and the drainage and piping of the hull will be first-class and complete.

The machinery of these vessels includes a vertical direct acting surface condensing compound engine, driving a single screw. The cylinders are of the following dimensions: H. P., 22 in. dia.; L. P., 48 in. dia., and stroke, 36 in. At a piston speed of 780 ft. per min., 130 revolutions, the engines are designed to indicate about 1,250 I. H. P. The condenser is separate from the engine frame. It is about 5 ft. in dia. and is located just abaft the main engine and over the thrust bearing. It has a cooling surface of 2,500 sq. ft., the tubes being of brass, 3-4 in. dia., tinned both inside and out. There are two single ended Scotch boilers in each vessel built for a working pressure of 140 lbs. The mean dia. of these boilers is 14 ft. 6 in. They are 12 ft. long, and each contains 3 corrugated Morison suspension furnaces 48 in. inside dia. The total heating surface of the two boilers is 4,600 sq. ft., and the total grate area is 168 sq. ft. The ratio H. S. to G.S. is 27.4, and the ratio G.S. to Calorimeter area is 7.2.

It will be seen by these figures that the boiler power is unusually large. The boilers under natural draft will be capable of supplying steam for about 1,700 I.H.P. The average American vessel is under powered in the boiler room, but this will certainly not be the case with the tugs here described, for if one boiler or one-half the steam generating plant is placed out of service on account of some mishap, the other boiler, by using the ventilating blower, will be capable of furnishing all the steam the engine could take care of under ordinary working conditions. Each boiler has its own stack, and above the deck house they are 30 ft. high and 5 ft. outside diameter.

The new tugs will have an excellent equipment throughout, for the owners have given the builders a free hand and they will deliver the vessels complete in every respect and ready for service.

AMENDMENTS TO THE U. S. STEAMBOAT RULES AND REGULATIONS FOR 1900.

At the regular meeting of the Board of Supervising Inspectors of Steamboats, held in Washington, D. C., last month under the direction of Supervising Inspector General James A. Dumont, amendments to the existing steamboat rules and regulations were adopted. Following is the text of the rules amended in part only, the parts struck out enclosed in brackets [thus], while the additions to such paragraphs are printed in *italics*. Entirely new sections and paragraphs of sections are in plain type, preceded by the word (new) in parenthesis:

RULES.

Rule I.

SECTION 1. (Proviso added to section, new.)

Provided, however, That where butt straps are used, the stamps in corners shall be extended to a distance not to exceed 8 inches from the edges.

SECTION 4. (First paragraph.)

4. The manufacturer of any boiler to be used for marine purposes shall furnish the inspectors of the district where such boiler or boilers are to be [constructed] *inspected* a blue print or tracing descriptive of same for their approval, which shall be kept on file in their office. * * *

SECTION 5. In both terms of affidavit of manufacturer of marine steam boilers, the words "Holes drilled, ———, or punched" were struck out, and the words "Rivet holes in the shells, heads and flanges of same, steam and mud drums, and holes for stay bolts, drilled and no part punched ————" inserted in lieu thereof.

Rule II.

SECTION 2. (First paragraph.)

* * * The pressures allowable on single-riveted boilers will be found in the first divisions of the double columns (of table) under the tensile strength and opposite the diameters and thickness; and in the second divisions the pressures allowable on boilers where all the rivet holes have been fairly drilled [instead of] *and no part of such holes has been* punched and the longitudinal laps of their cylindrical parts double riveted.

SECTION 2. (Second paragraph.)

All boilers built for marine purposes shall be required to have the rivet holes in the [shell, heads, steam and mud drums, and all other parts of the boiler (excepting for longitudinal and circumferential seams in flues for same 20 inches outside diameter and under), fairly drilled instead of punched], *shells, heads and flanges of same, steam and mud drums, and holes for stay bolts, fairly drilled, and no part of such holes shall be punched.*

SECTION 9. (Paragraph top page 31, Rules and Regulations, 1899.)

Tubes, water pipes, and steam pipes, made of [steel manufactured by the Bessemer process, may be used in any marine boiler when the material from which such pipes are made does not contain more than .06 per cent of phosphorus and .04 per cent of sulphur, to be determined by analysis by the manufacturers, verified by them, and copy furnished the user for each order tested; which analysis shall, if deemed expedient by the Supervising Inspector-General, be verified by an outside test at the expense of the manufacturer of the tubes or pipes]. *Bessemer, acid, or basic open hearth steel shall be required to show the following physical tests, namely, elastic limit per square inch* 30,000 *to* 35,000 *pounds, tensile strength* 50,000 *to* 60,000 *pounds, elongation in* 8*-inch specimen* 20 *to* 25 *per cent, reduction of area* 45 *to* 50 *per cent.*

The manufacturer of boiler tubes shall be required to furnish copies of reports of physical tests of every order for tubes to be used in marine boilers to the boiler maker using the same, and a similar copy to the Supervising Inspector-General, to be filed in his office. No tube increased in thickness by welding one tube inside of another shall be allowed for use.

SECTION 17. (New paragraph, after the fifth paragraph or example.)

To find the radius of sphere of which the bumped head forms a part, square the radius of the head. Divide this by the height of bump required. To this result add height of pump. This will give diameter of sphere, one-half of which will be the radius required.

SECTION 38. (Sixth paragraph.)

The flanges of all copper steam pipes over 3 inches in diameter shall be made of bronze or brass composition, *shall be securely brazed to pipe*, and shall have a thickness of material of not less than four times the thickness of material in the pipes plus .25 of an inch; and all such flanges shall have a boss of sufficient thickness of material projecting from the back of the flange a distance [of not less than three times the thickness of material in the pipe] *sufficient to be properly riveted to the pipe and of a thickness of not less than one-half inch;* * * *

SECTION 38. (New, added to 13th paragraph.)

No connection between shell of boiler and mud drum exceeding 6 inches in diameter will be allowed.

SECTION 40. (Amended.)

40. No cast-iron nozzles, branch pipes, or elbows shall be used in connecting steam drums, super-heaters, branch pipes, or steam pipes to boilers, and *in no other part of steam pipes. Flanges welded to wrought-iron, Bessemer, or other steel pipe may be used.* No cast-iron flanges will be allowed to be used on boilers for marine purposes unless such cast iron has been officially tested and test on record in the office of the local inspectors where boiler with such appliances was constructed, and no cast-iron with a tensile strength of less than 30,000 pounds will be permitted to be used for such purposes. *Semi-steel of not less than* 24,000 *pounds tensile strength may be used for nozzles, stop valves, branch pipes, elbows, slip joints, flanges to boilers, tee pipes, and water and gauge cock pipes or columns, when said semi-steel has been officially tested, and test on record in the office of the local inspectors, same as is required of cast iron.*

Rule III.

SECTION 24. (Amended.)

24. All steam vessels certificated as ocean [lake, bay, or sound] at their annual inspection after the adoption of this rule (except vessels of 100 tons and under, inspected under the provisions of section 4,426, Revised Statutes, and freight and towing steamers, inspected under the provisions of section 4,427, Revised Statutes) shall be provided with a line-carrying projectile and the means of propelling it, such as may have received the formal approval of the Board of Supervising Inspectors.

Rule IV.

SECTION 14. (New, added to Section.)

Each and every steam vessel applying for inspection on and after July 1, 1900, shall be fitted with a bilge pipe connecting by a suitably marked valve with the main bilge pump in the engine room, and each compartment of all steam vessels shall be fitted with a suitable sounding pipe.

Rule V.

SECTION 1. (Last clause of third paragraph.)

[New licenses may also be issued in the case of license lost by wreck, fire, or any other cause, upon a satisfactory showing of such loss to the inspectors, duly sworn to.] *In case of loss of license of any class, from any cause, the inspectors, upon receiving satisfactory evidence of such loss, shall issue a certificate to the owner thereof, which shall have the authority of the lost license for the unexpired term, unless in the meantime the holder thereof shall have the grade of his license raised after due examination; in which case, a license in due form for such grade may be issued.*

SECTION 1. (Last paragraph.)

* * * and no license shall be issued as above except upon the official recommendation of the chief officer in command of the naval *militia* station of the State in which the applicant is serving.

SECTION 9.

9. Masters and pilots of [passenger] steamers *carrying passengers for hire* shall exclude from the pilot

houses of such steamers, while under way, all persons not connected with the navigation of such steamers, except officers of the Steamboat Inspection Service, licensed officers of steamboats, persons regularly engaged in learning the profession of pilot, officers of the United States Coast Survey, Lighthouse Service, and engineer officers connected with the improvement of rivers and harbors. [The supervising inspectors, however, shall have the power, if in their judgment it will not endanger life on board of such passenger steamers, to grant permits authorizing the masters of such steamers, except when such steamers are making excursions under permits granted by the inspectors, to allow a limited number of such persons as they may deem proper in the pilot house of such steamers between the hours of sunrise and sunset, on the condition that such persons will not in any way interfere with the pilots in the performance of their duties. In the case of any violation of the conditions of any such permit it shall, upon demand, be surrendered to the supervising inspector having jurisdiction, and no such permit shall again be issued to any such master by any supervising inspector except the supervising inspector of the district to whom it was surrendered, and not by him until it shall be shown to his satisfaction that all the provisions of such permit will thereafter be complied with.]

The master of every passenger steamer shall keep three printed copies of this section of Rule V posted in conspicuous places on such steamer, one of which shall be kept posted in the pilot house.

Such printed copies shall be furnished by the Treasury Department to local inspectors for distribution among the passenger steamers of their respective districts.

SECTION 10. (Last paragraph struck out.)

[In case the applicant shall be found incompletely color-blind the local inspectors shall examine with the colored signal lights, and if satisfied that the applicant can sufficiently distinguish the color signals used on steam vessels they may, in their discretion, renew the license of such applicant.]

SECTION 12. No original license for pilot of any route shall be issued to any person, except for special license on small pleasure steamers and ferryboats navigating outside of ports of entry and delivery, who has not been employed in the deck department of a steamer [or], sail vessel, *or barge consorts* for the term of at least three years preceding the application for license. * * *

SECTION 14. (Third paragraph.)

[And] No original license as master [or mate of ocean steamers, or of coastwise steamers plying upon waters of the ocean or high seas], *of ocean or coastwise steamers shall be issued to any person who has not had three years' experience on steam or sail vessels preceding the application, one year of such experience to be as chief mate of steam vessels. No original license as chief mate of ocean or coastwise steam vessels shall be issued to any person who has not had three years' experience on steam or sail vessels, and must have served one year as second mate of steam vessels, such service to be immediately preceding the application. No original license shall be issued to second mate of ocean or coastwise steam vessels who has not had three years' experience in the deck department of steam or sail vessels immediately preceding the application, one year of such service to be on steam vessels. And no original license as master or mate of ocean or coastwise steamers* shall be issued to any person, or grade of license raised, or route extended, who does not understand navigation, and who is not able to determine a ship's position at sea by observation of the sun, to obtain longitude by chronometer, and to determine ship's latitude by meridian altitude of either the sun, moon, or stars. The examination to determine his qualifications shall be in writing, which shall be kept on file in the office granting such license; and all examinations of other masters, mates, or pilots shall be in writing and kept on file for reference: *Provided, however*, that applicant for original license to act as master or mate of steam pilot boats, or of steamers engaged in the Atlantic, Pacific, or Gulf coast fisheries, *or of steam or sail vessels navigating between the ports of the Hawaiian Islands, or betwen ports of the island of Porto Rico*, shall only be subjected to such examination as shall satisfy the inspectors that the applicant is a competent coast pilot, capable of navigating such steamers.

SECTION 25. (Fourth paragraph.)

25. Starting, stopping, and backing signals for steam vessels navigating the waters of the eighth and ninth supervising inspection district, and so much of Lake Superior as is included in the fifth district.

* * * * * * *

There shall be used between the master or pilot and engineer the following code of signals, to be made by bell or whistle, namely:

1 whistle or 1 bell	Go ahead.
1 whistle or 1 bell	Stop.
2 whistles or 2 bells	Back.
[3 whistles or bells	Check]
[1 long whistle] *4 whistles* or 4 bells	Strong.
[1 long whistle] *4 whistles* or 4 bells	All right.

Two whistles or two bells [when the engine is working ahead will always be a signal to stop and back strong], *shall always mean back, irrespective of other signals previously given.*

Rule VII.

SECTION 1.

1. All double-ended ferryboats on lakes and seaboard shall carry a central range of clear, bright, white lights, showing all around the horizon, placed at equal altitudes forward and aft; also such side lights as specified in [section 4,233 of the Revised Statutes, Rule III, Paragraphs B and C], *paragraphs (b) and (c), Art. 2, Act of Congress approved June 7, 1897.* * * *

Rule IX.

SECTION 1.

1. The inspectors shall visit places where marine boilers are being constructed as often as possible, for the purpose of ascertaining and making a record of the stamps upon the material, its thickness and qualities; *except when material has been tested at the mills by an assistant inspector, when that officer's report of material, together with the boiler-maker's affidavit, may be accepted for the data required.*

SECTION 2. (New paragraph added at end of section.)

Local inspectors inspecting sail vessels carrying passengers on the ocean or on the high seas, of over one hundred gross tons, under the provisions of section 4,417, Revised Statutes, as amended by the act of Congress approved December 21, 1898, shall require such

sail vessels to be equipped with a life-preserver for every person on board, passengers and crew, and with such number of good and substantial life boats according to tonnage, in accordance with the requirements of section 12, Rule III., Rules and Regulations.

SECTION 8. (Third paragraph.)

All steam whistles shall be placed not less than 6 feet above the top of the pilot house of steam vessels where the height of the smokestack will admit the attachment of same below its top, when not hinged for passing under bridges, except upon steamers navigating the Red River of the North and rivers whose waters flow into the Gulf of Mexico, and steamers of less than 100 gross tons, whose steam whistles shall be placed not less than 2 ft. above the tops of their pilot houses; and *all double-ended ferry steamers and steamers similarly constructed shall have a steam whistle both fore and aft of the smoke pipe; or if only one whistle is used, said whistle shall be placed on the side of smoke pipe so that the steam, when whistle is blown, can be seen from either end of steamer;* and it shall be the duty of inspectors to enforce this rule at the annual inspection.

PILOT RULES FOR ATLANTIC AND PACIFIC COAST INLAND WATERS.

RULE II. When steamers are approaching each other in an oblique direction, as shown in the diagrams of the fourth and fifth situations, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other, which latter vessel shall keep her course and speed; the steam vessel having the other on her starboard side indicating by one blast of her whistle her intention to direct her course to starboard, and two blasts [if directing her course to port, to which the other shall promptly respond], *her intention of directing her course to port so as to cross the stern of the steamer, which signals must be promptly answered by the steamer having the right of way,* but the giving and answering signals by a vessel required to keep her course shall not vary the duties and obligations of the respective vessels.

RULE IV. (First paragraph.)

When steamers are running in a fog [or thick weather], mist, falling snow, or heavy rainstorms, except when towing, it shall be the duty of the pilot to cause a long blast of the whistle to be sounded at intervals not exceeding one minute.

RULE IV. (Last paragraph struck out.)

[Steamers, when at anchor in the fairway of other vessels in a fog or thick weather, shall ring their bells at intervals of not more than two minutes.]

A statement prepared by the Paymaster General of the Navy shows that more than half of the emergency fund of $50,000,000, appropriated by Congress for the fiscal year ending June 30, 1898, was expended by the Navy Department. The total foots up $27,356,863. Among the various items which contribute to this total are: Purchase of vessels, $7,431,765; new construction and repairs, $1,112,515; Bureau of Ordnance, $5,582,888; purchase of guns, ammunition and supplies abroad, $1,327,017; hire and expenses of chartered vessels, $475,422; Bureau of Equipment, $399,937.

DETAILS OF CONSTRUCTION AND OPERATION OF RUSSIAN ICE BREAKER ERMACK.

In the last issue of the Notes on Naval Progress by the United States Office of Naval Intelligence there is an extended reference to the Russian ice breaker *Ermack*, accompanied by plans of the vessel. These we reproduce, together with other interesting information concerning this remarkable vessel which has not been published in previous references to her in these columns.

Fully three times as powerful as any vessel (ice breaker) previously constructed, the *Ermack*, designed by Vice-Admiral Marakoff, of the Russian imperial navy, and built last year in England by W. G. Armstrong, Whitworth & Co., for the Russian Government, deserves particular study, by reason of the novel features in her construction. Her principal dimensions are as follows: Length, 305 feet; beam, 71 feet; depth to upper deck, 42 feet 6 inches. At no point are the lines of her hull straight, thus assisting in disengaging her from fields of ice when there is danger of her being frozen in. This form of hull and the great strength of the structure would result in the ship being lifted bodily rather than giving way in case the ice closed about it. The strength and rigidity of the hull are so great, in fact, that if the ship should be suspended by the bow and stern without any intermediate support no damage could ensue. The heavy web framing and the plating of ice belt extending entirely around the hull, like the armor of a modern warship, with a maximum thickness of 1 1-4 in., render the outer skin impregnable to attacks of ice.

The *Ermack* has her bow designed with a very long overhang, so that the attack on the ice takes the form of a sliding blow, and if the resistance encountered is more than sufficient to overcome the breaking strain thus produced, the momentum of the vessel is expended in lifting the bow on to the top of the ice. Meanwhile the water supporting the ice is violently disturbed by the action of a propeller arranged under the cutaway bow, so that under the effect of the weight of the vessel acting above and enhanced by absence of support below the ice gradually yields. The action thus described will take place continuously when working in thick ice. The foremost part of the bow is composed of a solid steel casting. Three screws are placed at the stern, one being on the center line, as in ordinary single-screw vessels, and the other two as in the usual twin-screw arrangement. The four screws are arranged so that large blocks of ice may be carried clear of the hull or out of the way of the advance of the vessel by means of the current or race due to their working.

It is hardly necessary to say that an ice-breaking steamer, to be effective, must have remarkable manœuvering powers, as vessels working in frozen seas have the very smallest space to turn in at times. For this reason the twin-screw arrangement was desirable; but with twin screws the efficiency of the rudder may be lessened, as the propeller race is not thrown directly upon it, as is the case with one screw directly forward of the rudder. The bow screw is not introduced for speed purposes, but simply to enable the ship to clear her way and keep lumps of ice from accumulating un-

der her bottom. All four propellers are four-bladed, made of nickel steel, and enormously thick, being calculated to be brought up by ice without breaking when running at full speed. The machinery is all designed to withstand this test.

The vessel is divided into forty-eight absolutely water-tight compartments, of which fourteen are in the double bottom. There is one cross bunker for coal, as well as side bunkers. The fore and after peaks are arranged for trimming purposes, so as to bring the vessel by the head or stern with water ballast. There are also two heeling tanks amidships. In case the ice crowds the ship on one side the tank on that side can be filled, and an extra pressure of some hundreds of tons brought to bear on it so as to right the ship and crush the ice down into the water. Both tanks would be filled if it were found that the ice was raising the ship bodily. The weight and shape of the *Ermack* would make her roll considerably in a sea way, and she cannot have bilge keels, since they would afford a grip hold for the ice; therefore, she has also been provided amidships with a third, or anti-rolling, tank. Connected with these tanks are pumps of enormous power, so that if the vessel gets caught in the ice her horizontal plane may be varied in any sense desired, whereby she may the more readily release herself.

The pump room is a well perfectly watertight, let into the middle of the vessel and descending to within seven feet of the bottom. The salvage pump has a capacity of ten tons per minute, and if the ship were flooded above the level of this pump the latter would be still accessible. The ballast pump is arranged so that it can take hot water from the boilers and pump it into the fore peak, the hot water overflowing through valves in the bow and running down the outside of the skin plating. This is designed with the purpose of preventing rough ice from adhering to the hull.

At the stern the vessel is shaped much like a cruiser, but instead of being rounded off has a deep groove, furnished with fenders, intended to receive the stem of another steamer of the ordinary type in conducting her safely through the broken ice. By means of a powerful winch the second steamer may be braced up taut, and thus be enabled to add her power to that of the ice breaker in struggling with the ice.

Another interesting feature is the so-called ice box, an open tube amidships from the main deck down to the water under the ship's bottom. Through this the boilers are fed with water direct from the sea beneath. This tube is connected with a glass pipe set against a wooden scale, on which are marked on one side the number of feet that the vessel is drawing, and on the other the number of tons which the ship displaces at that draft. The total displacement of the *Ermack* is 8,000 tons: indicated horse power of the engines, of which there is a set of the triple expansion type to each propeller, is 12,000, giving a maximum speed, it is understood, of 16 1-4 knots. The results of the steam trials showed that the speed with 8,000 I. H. P. was nearly 15 1-4 knots.

Experience with the *Ermack* has shown that pack ice of practically any thickness can be negotiated. On one occasion she encountered a pack which was measured and found to be of a total thickness of 34 feet, nine feet being above the level of the field, and through which she successfully forced her way, a feat which would have been quite impossible but for the action of the forward propeller.

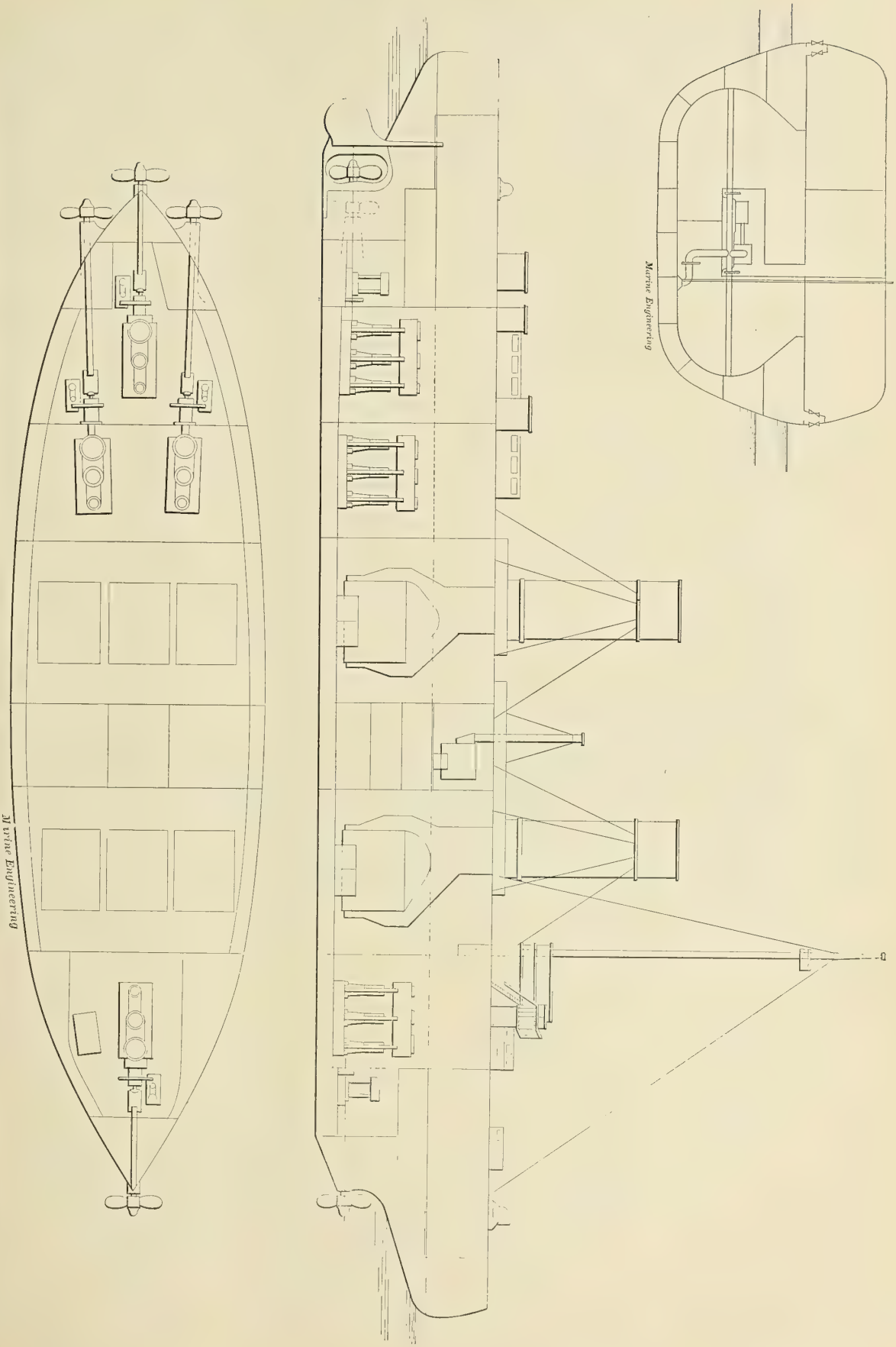
As a factor in naval operations it is not difficult to estimate the possibilities of a vessel like the *Ermack*. It looks as if the Russian fleet can no longer be considered as icebound when wintering in the Baltic ports or Vladivostock—a fact of very considerable importance in the event of Russia finding herself engaged in a naval war. Moreover, the vessel itself would be distinctly formidable as a ship of war. As a ram she would be a deadly weapon of offense if she once got her blow home, especially on a ship with a low freeboard, for she would bear her down by her overwhelming weight until she filled and sank, while the *Ermack* herself would be invulnerable as long as her engines and boilers, which are exceptionally protected, were intact.

According to latest advices (October 19, 1899), the *Ermack* is shortly to take up a more important work than ever. This is to keep navigation open during the winter, not only between St. Petersburg and Cronstadt, a distance of twenty miles, but also as far as Reval and Libau on the Baltic. If the *Ermack* succeeds in keeping the Gulf of Finland and the Baltic open to navigation the shipping trade of St. Petersburg will be greatly affected thereby. Hitherto the shipping trade of the capital and Cronstadt has been impossible for about six months of every year. During the winter a certain amount of trade is carried on by rail to those Baltic ports which happen to be open to navigation.

The trials of the *Ermack* commenced with a four hours' consumption run, with the main propelling engines developing a combined horse power of 8,000, when the consumption of coal was found to be 1.52 lb. per I.H.P. per hour. The machinery was then driven at full power, with the three after propellers working ahead, and the forward propeller astern, or in opposition to the after ones. Under this condition the engines developed 11,250 horse power, a speed of close on 16 knots being attained, or practically the same rate as when all four screws were running ahead. On the completion of these trials the main propelling engines were disconnected, the auxiliary screw engines connected to the shafts, and the ship driven at a slow speed, the results throughout being highly satisfactory.

During the protracted two days' trials of the ship thick weather prevented the section post on the measured mile from being seen, and speed was, therefore, taken by log. The practical result which has been arrived at seems to be that the speed with 8,000 horse power was nearly 15.25 knots. The speed with the three after engines working ahead was about 15.5 knots, and the speed with all the engines running ahead was about 16.25 knots, the power in each case being at the maximum. The highest indicated power developed was 12,000 horse power, and this corresponds with the speed of 16.25 knots. With the three after engines working ahead and forward engine working astern the power was 11,250, of which the forward engine was never developing more than 2,000 horse power.

The *Ermack*, in a trip to the northwest of Spitzbergen, passed through 200 miles of ice of an estimated thickness of about 14 ft.



CROSS SECTION, ELEVATION AND HOLD PLAN OF THE STEEL FOUR SCREW ICE BREAKING STEAMER ERMACK, BUILT IN ENGLAND FOR THE RUSSIAN GOVERNMENT.

DISINFECTING STEAMER SANATOR FOR THE U. S. MARINE HOSPITAL SERVICE.

BY C. M. GREEN, FIRST ASS'T ENGINEER R. C. S., SUPERINTENDENT OF CONSTRUCTION M. H. S.

An interesting example of unusual marine construction is found in the new disinfecting steamer *Sanator*, just completed by the Kensington Engine Works of Philadelphia for the United States Marine Hospital Service.

The efficiency of a floating disinfecting plant has been fully demonstrated, notably by the successful and rapid disinfection of troops and troop ships at Montauk Point in the fall of 1898 by means of the disinfecting barge *Protector*, then just completed for the Marine Hospital Service. Had no such apparatus been available at that time, the spread of disease from the troops returning from Cuba might have been very disastrous.

The disinfecting vessel *Sanator*, now being fitted out for service at the port of Havana, was designed under the supervision of the Bureau of Marine Hospital Service, and is provided with the most improved Kinyoun-Francis disinfecting and fumigating machinery, the whole plant being a decided improvement on that of the barge *Protector* and undoubtedly the most complete floating disinfecting plant in the world.

The *Sanator* is a low powered steam vessel capable of making a maximum speed of about 8 knots, this being sufficient to enable her to reach her station and to move around the harbor as may be required.

CONSTRUCTION OF HULL, ETC.

In construction the hull is framed of Delaware oak, planked inside and out with yellow pine and decked with Oregon pine. The use of wood for the construction of the hull was necessitated by the fact that a steel hull is quickly corroded and eaten away by the solution of bichloride of mercury, which is one of the disinfectants used in considerable quantities on the vessel and which cannot be kept out of the bilge.

The construction of the hull is very staunch and well suited for the purposes intended. The dimensions are as follows:

Length over all	161 ft. 6 in.
Length from forward edge of stem to after edge of stern post	149 ft. 11 in.
Beam, extreme on water line	32 ft.
Depth of hold from top of deck beams at side to top of ceiling at keelson	12 ft.
Depth from top of main deck beams at side to top of keel	13 ft. 3 in.
Camber of deck beams	6 in.
Draft, normal, forward	7 ft. 3 in.
Draft, normal, aft	8 ft. 3 in.
Displacement, normal	640 tons.
Displacement, tons per inch at L. W. L.	9.4 "
Distance center to center of frames	26 in.
Depth of keel below bottom planking	9 in.

The keel is of oak 10 in. by 12 in. in four sections with keyed scarfs secured by copper bolts. The keelson, 10 by 16 in., is of yellow pine, scarfed in three sections. The frames are of oak, sided 6 in. and moulded 12 in. at the throat and 6 in. at the deck. The deck beams are of yellow pine, sided 10 in., 13 in. deep at the center and 7 in. at the ends. They are secured by hackmatack lodging and hanging knees well fastened. The bottom and inside planking is 3 in. thick and the top sides 4 in. thick. The clamps are 4 by 12 in., and 4 by 8 in. planking is carried from the clamps clear down to the lower turn of the bilge and 3 in. ceiling to the keelson. The deck is 3 in. thick, increased to 4 in. under the windlass and around the mast.

The frames are brought up through the plank shear and form stanchions for a heavy rail extending unbroken entirely around the vessel. There is a solid waist with four freeing ports. A heavy guard extends entirely around the vessel at the sheer strake and the sides are kept clear so that other vessels can come alongside without damage.

The stem and apron are made of oak in one piece, sided 10 in. Towing bitts are located near the stem. The hawse pipes are very large, to provide for patent stockless anchors. The stern post is of oak, 12 by 17 in. at the propeller boss and 12 by 10 in. elsewhere. The rudder post is of oak, 10 by 12 in. The rudder is 5 ft. wide, and fitted with heavy composition braces and pintles. The stock is 12 in. dia. of oak. The steering gear is of the double purchase hand pattern. Bilge keels, 8 by 10 in., extending for a distance of 80 ft. amidships, are provided to reduce rolling in a sea way. The hull is coppered to a mean draft of 8 ft. 6 in.

The hold is entirely floored over 12 in. above the keelson, giving a large space for the reception of disinfecting and auxiliary machinery. At each end are raised platform decks to increase the floor space.

There are two cross bulkheads forming between them the infected compartment of the hold into which is taken all baggage, clothing and effects to be disinfected. This compartment contains the forward ends of the two steam disinfecting chambers with the doors, cars and tracks, and also a vat for bichlorate of mercury for disinfecting certain articles by immersion in this solution. Above this compartment is a hatch 8 ft. square from the main deck and also clothes hatches from the two disrobing rooms in the deck house. This compartment is provided with lockers and racks, but is so built as to be easily disinfected or fumigated as may be necessary after infected goods are handled.

Forward of the infected compartment is another compartment also provided with large hatches. This space contains the chain lockers, paint locker, sulphur bins, two large sulphur furnaces with smoke pipes, sulphur pipes, exhauster and engine, two store rooms and two large fresh water tanks, the latter being located under the raised flooring.

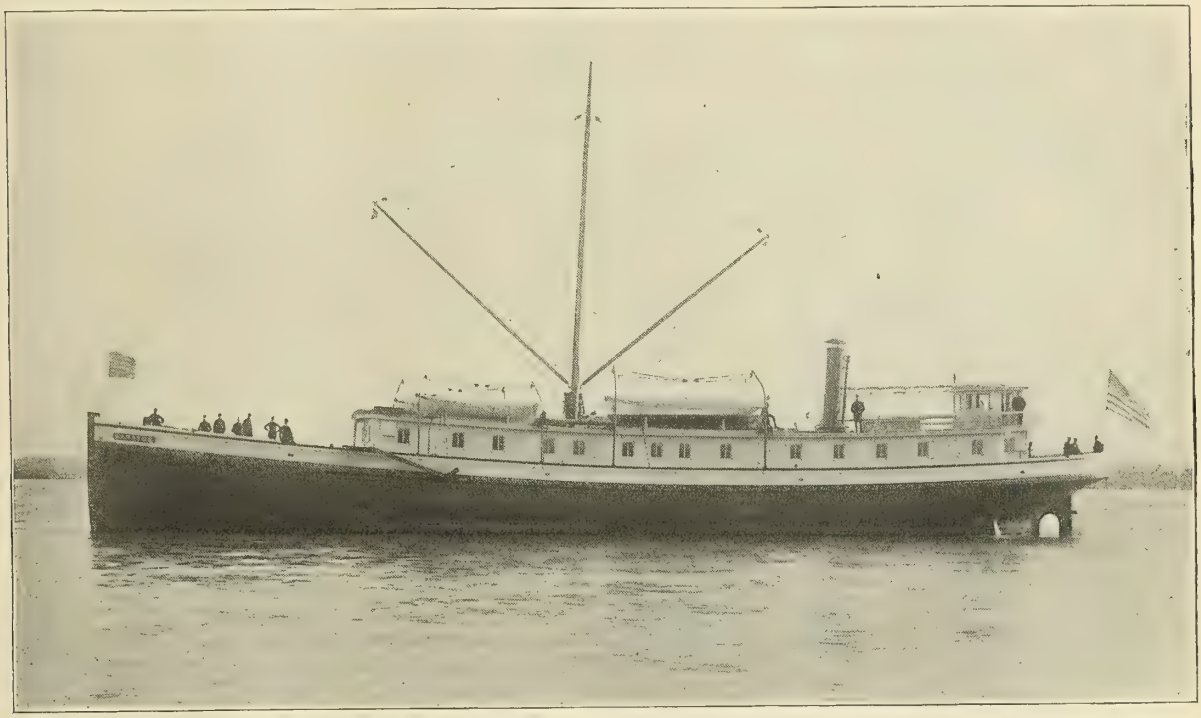
The space aft of the infected compartment is the largest compartment in the vessel. In its forward end are the two steam disinfecting chambers, with the formaldehyde gas and ammonia generators, the steam exhauster, cars, tracks, doors and attachments. Goods after being disinfected in the chambers are brought through this compartment and taken up through the after hatch which is 8 ft. square. At the sides abreast of the steam chambers are two fresh water tanks.

Aft of these are two storage batteries for lighting purposes. This storage battery system is believed to be the first ever installed in a vessel for the United States Government. Abaft of these are the ventilating blower and engine on the starboard side and the dynamo room on the port side. This latter room contains besides the engine and dynamo the switchboard and connections and a tool locker. Next to the dynamo room is another large water tank near which is located

the steam fire pump. On the starboard side is an 1,800 gal. tank for bichloride of mercury solution, and near it a special steam pump connected to force the solution through pipes and hose connections to all parts of the vessel or to a vessel alongside, as may be necessary.

Next to these tanks and outboard of the after hatch are the two single ended Scotch boilers, and outboard of these are two more water tanks. Next to these are the two coal bunkers holding together 30 tons of coal. Between the coal bunkers is the main engine, the main feed pump, the water service pump, the condenser, air, and circulating pumps, and feed tank. On the raised platform aft are the pressure supply tank, oil tanks, lockers, work bench and a large ice box and refrigerator.

On the main deck forward is a steam windlass for handling the anchors and also arranged for working the two derrick booms. Aft there is a hand deck pump arranged for use as a bilge or fire pump. A side ladder which can be shipped on either side of the vessel is provided and also a sea ladder.



DISINFECTING STEAMER SANATOR FOR U. S. MARINE HOSPITAL SERVICE AT HAVANA, CUBA.

DECK HOUSE.

The deck house, 24 ft. 6 in. wide, extends for a distance of 99 ft. and has an extension at the after end 7 ft. 2 in. long, on which is located the pilot house. It is divided into two parts, the quarters aft and the rooms for handling infected persons forward. A fore and aft bulkhead separates the forward part into two divisions which may be used for males and females as required.

Infected persons are brought on board by the side ladder near the forward end of the deck house. They enter the forward or disrobing rooms, there being one on each side. Their clothing is lowered through the clothes hatches to the infected compartment of the hold, where it is sorted and disinfected, going through the steam chambers and up the after hatch. The persons being treated meanwhile pass from the disrobing rooms to the bath rooms, immediately aft, where are six shower bath rooms and four rooms, each with a tub and shower. After bathing they go to the dressing rooms, where their clothing has been delivered after disinfection. They then pass to the waiting rooms, where they remain until taken ashore or to their vessel.

The after part of the upper deck is provided with awning and benches and can be used by waiting passengers in good weather, there being a stairway connecting it with the waiting rooms below.

The quarters for officers and crew in the after end of the deck house comprise a mess room, nine staterooms, with two berths each; a galley, storage closets and lockers. There are two water closets in the after end of the house and two connected with the dressing rooms.

Besides the eighteen berths in the staterooms, thirty-eight berths are provided in the forward rooms of the deck house. These can be taken down and stowed under the transom seats in those rooms when not required. These berths are for use when passengers are to be detained over night. Two of the staterooms can also be used for this purpose or for temporary hospital purposes.

The pilot house is placed on the extreme after end of the deck house in order to leave ample working space for the two derricks and the sulphur pipes and hose on the upper deck.

A single derrick mast is located midway between the two main hatches, and two booms, one for each

hatch, are provided for handling baggage. These derrick booms are worked by the steam windlass and are designed to lift 1,500 lb. each. The mast is also provided with the necessary rigging for enough sail to keep the vessel out of the trough of the sea in case the machinery should become disabled while going from port to port. The sails and rigging are removed when the vessel is stationed in port.

On the upper deck, in addition to the gear for the derricks, are the sulphur pipes, sulphur hose locker and the boats with their cradles, davits and attachments and also three skylights for lighting the rooms below.

BOAT EQUIPMENT.

The boats carried include one 25 ft. alco-vapor launch and two 18 ft. dinghies. The launch is provided with a 5 horse power engine and is very completely fitted out with all necessary attachments, awning, cork cushions, lines and anchor. The 18 ft. boats are provided with masts and sails.

DISINFECTING MACHINERY.

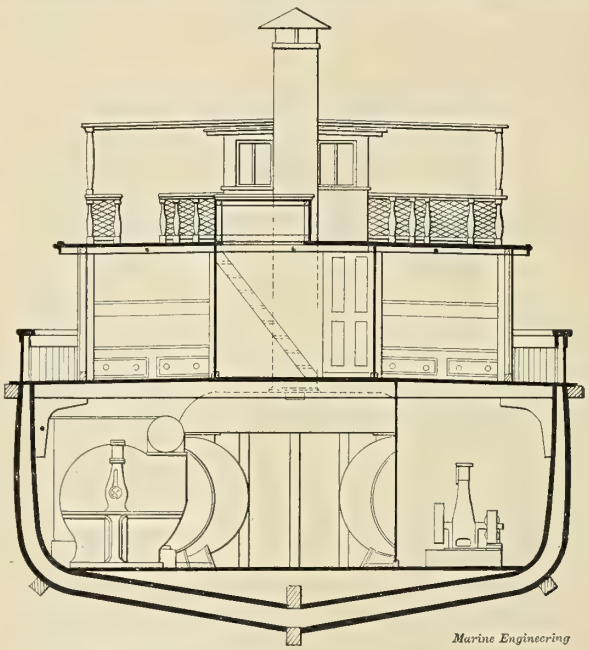
There are two steam chambers located side by side, with their forward ends projecting through the bulkhead into the infected compartment of the hold. In shape they are cylindrical, about 60 in. dia. outside, and 16 ft. long. Each is constructed with an inner and outer steel shell 1 3-4 in. apart, forming a steam jacket, the ends being riveted to heavy cast iron rings and the shells stayed with screw stays. The inner diameter in the clear is 55 in.

At each end is a heavily constructed quick opening door formed of a dished and flanged steel plate 1-2 in. thick. The flange of the door bears against a square rubber gasket fitted in a groove in the cast iron end ring. The door is held shut by heavy steel radial arms bearing against an internal groove in the end ring and against blocks near the outer flange of the door, the inner ends of the arms being held in by a large nut and hand wheel working on a stud at the center of the door. An arrangement is provided for quickly withdrawing the radial arms from the groove in the end ring, thus permitting the door to swing open on a special davit and arm provided for the purpose. Ball bearings are provided in all parts, and although the door is heavy and designed to sustain a total pressure of about 38,781 lb., it can be opened or closed in less than one minute.

The chambers are built to carry a working pressure of 10 lb. per sq. in. They are covered with magnesia covering and are fitted with a complete system of steam and exhaust pipes, drains and traps. A Korting steam exhauster is connected with both chambers, which is capable of producing in either a vacuum of 15 in. in less than one minute.

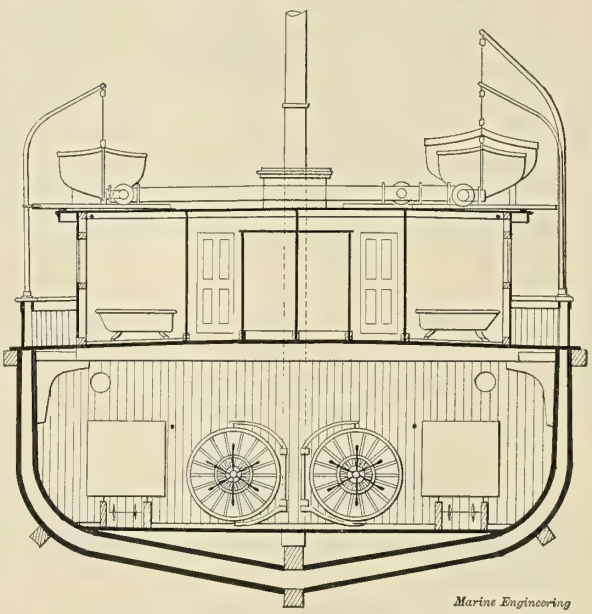
The drainage is led through two steam traps to two drainage tanks under the hold floor, these tanks being emptied overboard by a steam ejector. Steam and vacuum gauges, safety valves and thermometers are provided, and reducing valves are fitted in the steam supply pipes to regulate the pressure. The steam inlet to the interior of the chamber is at the top, and a copper hood extending the whole length of the chamber is provided to prevent steam impinging directly on the goods being disinfected.

Through each chamber near the bottom runs a double track of angle iron with movable extensions to transfer-tables at both ends. Along these tracks can be moved cars of light wrought iron construction containing the goods to be disinfected. These cars are provided with removable galvanized wire trays, brass



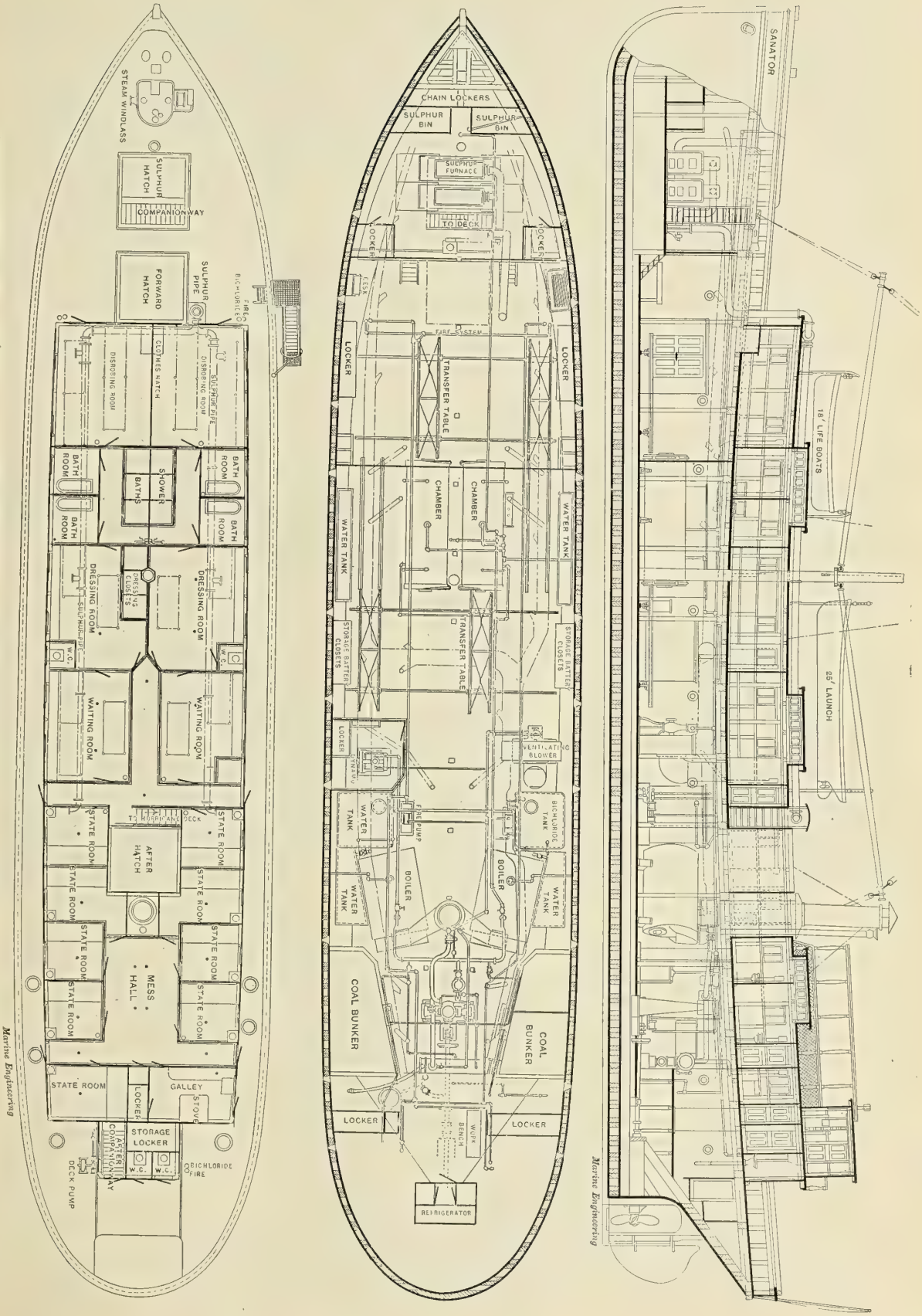
CROSS SECTION OF DISINFECTING STEAMER SANATOR.

hooks, and galvanized wire folding baskets, either of which may be used, depending on the character of the goods being treated. They are loaded with infected goods or clothing while on the transfer-tables in the infected compartment and then pushed into the steam



CROSS SECTION OF DISINFECTING STEAMER SANATOR.

chamber where the disinfection is accomplished. The after doors of the chambers are then opened and the cars brought out on the after transfer-tables where they are unloaded, the disinfected materials being taken up



Marine Engineering

INBOARD PROFILE, HOLD AND DECK PLAN OF THE DISINFECTING STEAMER SANATOR FOR THE U. S. MARINE HOSPITAL SERVICE AT HAVANA, CUBA.

Marine Engineering

the after hatch. The cars are then moved outboard on the transfer-tables and taken forward along raised tracks at the sides of the chambers and through doors in the bulkhead into the infected compartment, where they are again loaded with goods to be disinfected. The length of time of the operation depends upon various conditions, but usually occupies about thirty minutes for each chamber. Steam is kept in the jackets of the chambers during the operation, so that the materials disinfected are thoroughly dried before being taken from the chamber. Four cars and four transfer-tables are provided.

FORMALDEHYDE APPARATUS.

Attached to brackets on the side of the starboard steam chamber is an apparatus for generating formaldehyde gas and ammonia gas. It is composed of two generators, one for each gas, secured in one cylindrical casing for compactness and convenience. Each generator consists of a horizontal closed cylinder containing a steam coil and provided with fillers, pressure gauges, safety valves, and proper pipe connections. The cylinder and pipes for formaldehyde gas are made of brass and copper, those for ammonia of cast steel and iron. Each is connected with both steam chambers, the purpose being to use formaldehyde gas for a disinfectant in either chamber when disinfecting any materials which would be injured by steam. The ammonia gas is used after the treatment by formaldehyde gas in order to neutralize the latter and prevent irritating effects on the mucous membrane of the attendants, from inhalation and contact with the goods treated. Either gas is generated by introducing into the generator the proper quantity (computing from the volume of the steam chamber) of formalin or a strong ammoniacal solution, as the case may be, and applying heat by means of the steam coil.

Before using either steam or formaldehyde gas in the steam chambers the air is removed by an exhauster and a vacuum of about 15 in. formed.

The vessel is to be provided with four Kinyoun-Francis autoclaves. These are portable formaldehyde gas generators, and can be taken into the cabins or rooms of a vessel alongside for disinfecting purposes, the rooms being tightly closed to prevent the escape of the gas.

SULPHUR FURNACES.

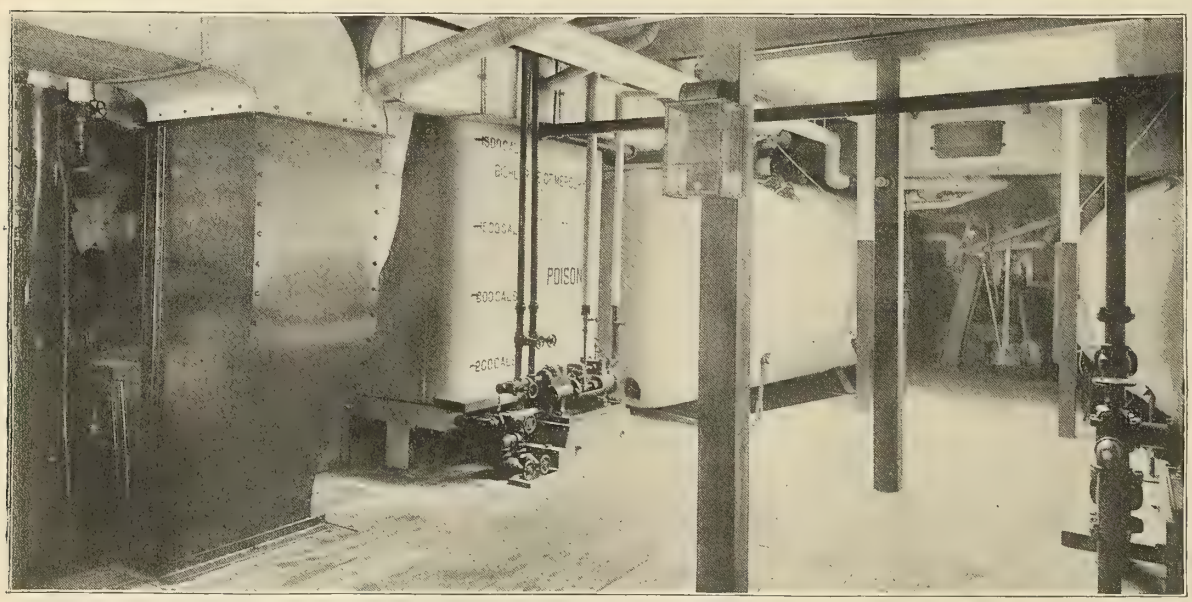
In the forward hold compartment are the two sulphur furnaces side by side athwartship. Each is built of steel with cast iron fronts, the dimensions being: length, 10 ft.; width, 3 ft.; height to top of reservoir, 6 ft. 6 in. There is a fire box at each end of each furnace, over these being shallow cast iron pans for the reception of the sulphur. Dampers and baffle plates are provided to regulate the supply of air and prevent too rapid combustion. On the top is a reservoir where the sulphur dioxide is collected. The smoke from the fire boxes is taken by a pipe near the bottom to a smoke-stack leading up through the main deck forward.

Pipes from the gas reservoirs connect to a high speed Sturtevant exhausting fan belted to a vertical engine, 5 in. by 6 in. This exhaustor delivers the sulphur gas through a 12 in. galvanized iron pipe leading through the main deck to branch pipes extending fore and aft on both sides of the upper deck. On each of these branch pipes are three connections for special 6 in. sulphur hose, by means of which the sulphur gas can be taken into any compartment of a vessel alongside to be fumigated.

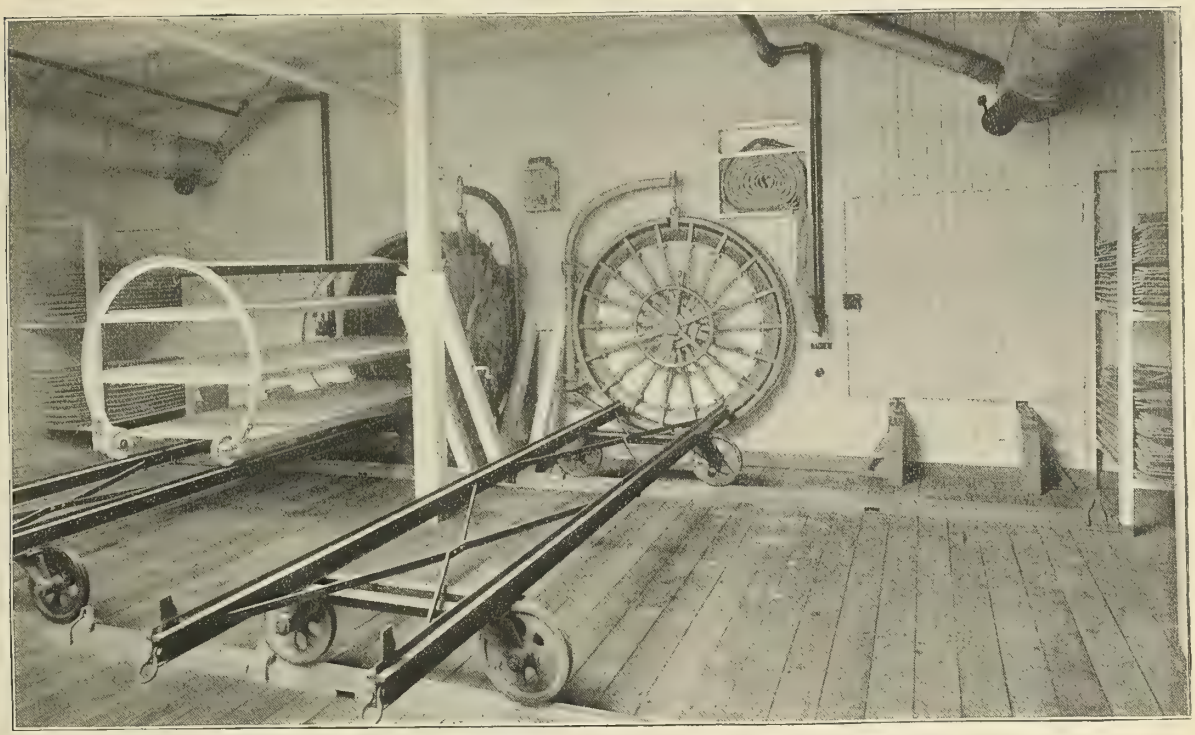
The sulphur furnaces and sulphur piping below the main deck are well covered with magnesia covering and the piping on deck is kept well clear of wood work. The sulphur bins forward of the furnaces hold together 40 barrels of sulphur.

BICHLORIDE OF MERCURY APPARATUS.

An 1,800 gal. steel tank for the storing of bichloride of mercury solution is located in the hold amidships on the starboard side. Above this in the deck house is a 40 gal. mixing tank with connections for steam and water as well as a connection to the large tank



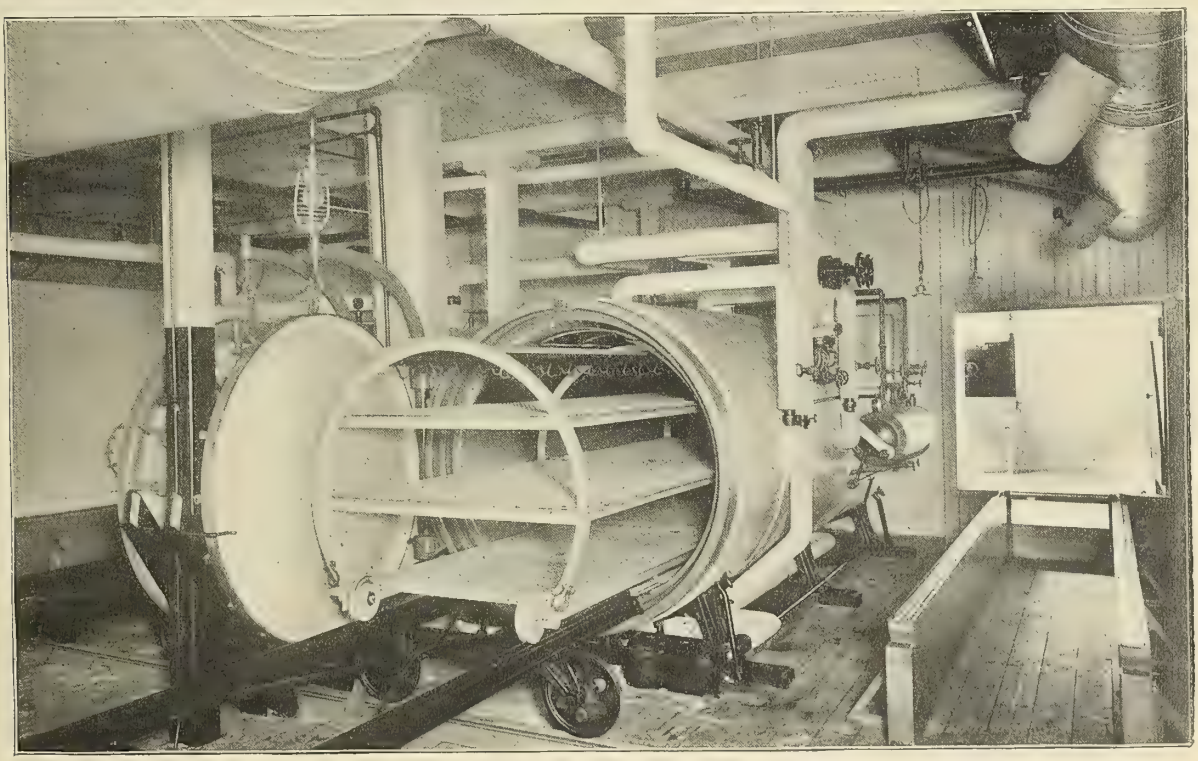
VIEW IN AFTER END OF HOLD OF S. S. SANATOR LOOKING TOWARD STARBOARD SIDE.



FORWARD ENDS OF STEAM DISINFECTING CHAMBERS IN INFECTED COMPARTMENT.

below. The proper quantity of the chemical is mixed in the small tank and allowed to flow into the large tank, into which has already been pumped a quantity of water sufficient to make the required solution.

Near the large tank in the hold is a special horizontal duplex pump, having steam and water cylinders of 4 1-2 and 2 3-4 in. dia., respectively, and a stroke of 4 in., its water cylinder, valve guards and connections being made of iron and the valves of rubber, it having been found that the bichloride solution acts less quickly on these materials than brass. This pump has suction connections to the sea, the bilge, and bichloride tank,



AFTER ENDS OF DISINFECTING CHAMBERS—CARRIAGE PARTLY RUN OUT IN FOREGROUND.

and delivers to the same tank, to the bichloride pipe system, or overboard. Its principal purpose is to take the solution from the tank and force it through the bichloride pipes to hose plugs located on the four corners of the deck house and to two hose plugs in the hold. By means of the 2 in. hose, and spray nozzles, the solution can be sprayed as a disinfectant in any part of the vessel or in any part of a vessel alongside being disinfected.

A bichloride vat is located in the infected compartment, into which articles may be dipped for disinfection.

BATHS AND WATER SUPPLY.

Bathing facilities are extensive; there are ten 10 in. showers and four porcelain-lined iron bathtubs located in the ten bathrooms in the deck house. These are supplied with water through Gegenstrom water heaters, the latter being supplied with thermometers and steam and water regulating valves. The heaters are located outside the bathrooms and the temperature of the water is regulated by an attendant.

The water supply is provided by connections to a pressure tank located on the after hold platform. A horizontal duplex pump provided with an automatic regulating valve supplies this pressure tank with fresh or salt water as may be required. The pump is so arranged as to maintain a constant pressure in the tank automatically. By means of a system of galvanized iron pipes this tank also supplies the nine wash basins in the staterooms and also the galley with fresh water.

The bathrooms and tubs are all provided with drains leading overboard, there being a 3 in. drain pipe on each side for this purpose. The wash basins in staterooms and galley sink are also provided with overboard drains.

BOILERS, ENGINE AND AUXILIARIES.

Two single ended Scotch boilers are placed in the hold outboard of the after hatch and just forward of the main engine. They are built for a working pressure of 110 lb. per square inch and are of the single furnace type. Their dimensions are: Length, 10 ft. 3 in., and diameter, 6 ft. 10 in. The furnaces are 39 in. internal diameter and the grates 6 ft. 6 in. long. The following data is for both boilers:

Heating surface, sq. ft	1,189.18
Grate " " "	42.25
Area through tubes, sq. ft	5.52
Area of smoke pipe, " "	5.58
Ratio, heating to grate surface	28.14
Ratio, grate surface to area through tubes	7.64
Ratio, grate surface to area through smoke pipe	7.57

The smoke pipe is 30 in. dia., and extends 30 ft. above the grates. A steam jet is fitted at the base, and also an exhaust nozzle which can be used when the engine is run non-condensing. A Worthington horizontal duplex feed pump is located on the starboard side of the engine room. It is 6 in. and 4 in. by 6 in., with suction connections to the fresh water tanks, the feed tank, the sea, and the bilge, and delivery both to the boilers and overboard. Two injectors are also fitted.

The main engine is of the inverted direct acting single crank type, with cylinder 17 in. dia. and 20 in. stroke. It is designed to develop 200 I. H. P. at about 150 revolutions. It is fitted with a single ported slide valve, and Myer cut-off gear. Cast iron columns form the framing and to these the slides are secured, the crosshead being T shaped with double pins. The thrust bearing bolts directly to the bed plate. No pumps are fitted to the engine, and the piping is arranged to run the engine condensing or non-condensing as desired. The crank shaft and pins, also the thrust and propeller shafts are 6 1-2 in. dia. Cast iron is used for the propeller, which is of the Trout pattern, a four bladed true screw, 6 ft. dia. and 7 ft. 4 in. pitch.

A combined surface condenser, air and circulating pump is located athwartship aft of the engine. Besides the connection to the main engine the condenser is connected to the auxiliary exhaust pipe, so that the auxiliaries can be run condensing if required.

A steel feed tank, with filter arrangement, 4 ft. 6 in. long, 18 in. wide and 30 in. deep is provided. The fire pump is of horizontal duplex pattern, with cylinders 6 in. and 5 3-4 in. dia. and 6 in. stroke. It is arranged to draw from the sea or the fresh water tank, or from water boats alongside, and the discharge has connections to the fire mains and to the fresh water tanks.

Seven large steel fresh water tanks are fitted, not including the bichloride of mercury tanks and smaller tanks already referred to. The capacity of the seven is 10,000 gallons of water.

LIGHTING PLANT.

For lighting the *Sanator* a Sturtevant direct driven marine set of 6 k.w. capacity is installed in the dynamo room on the port side of the hold. The engine has a cylinder 6 in. by 6 in., and the dynamo is a compound wound eight pole machine, with carbon brushes. Its capacity is 100 16 c.p. incandescent lamps. Slate is used for the switchboard, which contains the usual instruments and also a rheostat for the storage battery, with sufficient range to control from 10 to 70 lamps.

The storage battery, consisting of 60 cells, is located in two special lockers, one on each side of the hold. The lockers are provided with three inch lead vent pipes to carry off the acid fumes. There are 30 cells in each locker. The battery has a capacity sufficient to carry 50 16 c.p. 110 volt lights for 10 hours after being charged. Its total weight is 5,900 lb., including fittings. The weight of each cell filled is about 91 lb., the dimensions being 8 1-2 in. by 8 1-2 in. and 10 in. high. The cells are placed in lead-lined wooden troughs or boxes, there being fifteen cells in each. These boxes are sealed to prevent the acid spilling when the vessel is rolling. Each of the lockers containing the cells measures 2 ft. 8 in. by 7 ft. 3 in., and is 6 ft. 6 in. high.

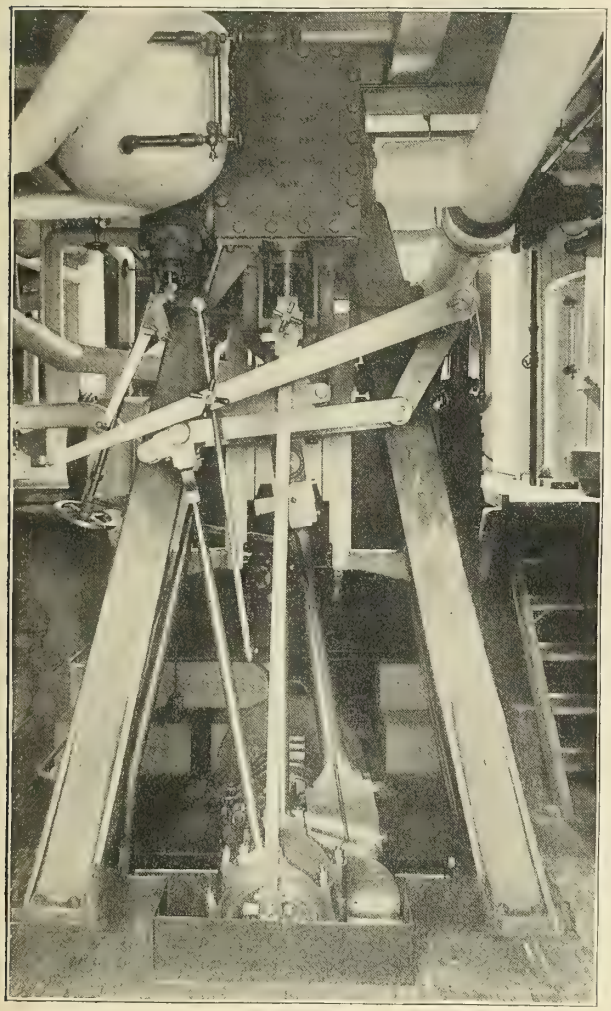
VENTILATING SYSTEM.

The ventilating plant consists of a Sturtevant blower and high speed engine, direct connected. The diameter of fan is 75 in. and its width 26 in. A suction duct 38 1-2 in. dia. passes up into the deck house and takes air through a grating on the starboard side of the house. The delivery pipe from the blower has branches of galvanized iron pipe extending to all parts of the vessel. A delivery louvre is located in each room of the deck house and at intervals on both sides throughout all compartments of the hold.

The ventilating plant is designed to entirely renew the air in all parts of the hold every five minutes, the

designed capacity of the blower being 12,000 cu. ft. of air per minute when it is making about 260 revolutions per minute.

In the way of handling gear and minor appliances there is a combined steam windlass and hoisting en-



SINGLE-CYLINDER; SINGLE-CRANK ENGINE, S. S. SANATOR.

gine, two Baldt stockless anchors, a double brake hand deck pump and a bilge ejector.

There are, of course, extensive storage facilities for the various supplies and disinfecting materials carried, and, altogether, the vessel is as complete as sanitation and engineering science can make it.

Loss of Coast Liner.—The steamship *Gate City*, of the Ocean Steamship Co., on a recent trip from Savannah to Boston, went ashore on the Great South Beach, Long Island. She stranded in a thick fog, about 10.30 o'clock at night. The life saving crew from the Moriches Station took off the women passengers, but the men on board decided to stay with the vessel. They were taken off at a later date, and much of the cargo of cotton was saved. The vessel is expected to be a total loss. On two previous occasions this vessel went ashore, but was successfully floated again. She was an iron steamer, built at Roach's yard, in 1878, of these dimensions: Length, 254 ft.; beam, 38 ft.; depth, 24 ft.; gross tonnage, about 2,000 tons.

COMMERCIAL TYPES OF WATER TUBE BOILERS BUILT IN AMERICA.—III.

DESCRIPTIONS OF BABCOCK & WILCOX, WATSON AND BOYER BOILERS WITH SECTIONAL DRAWINGS.

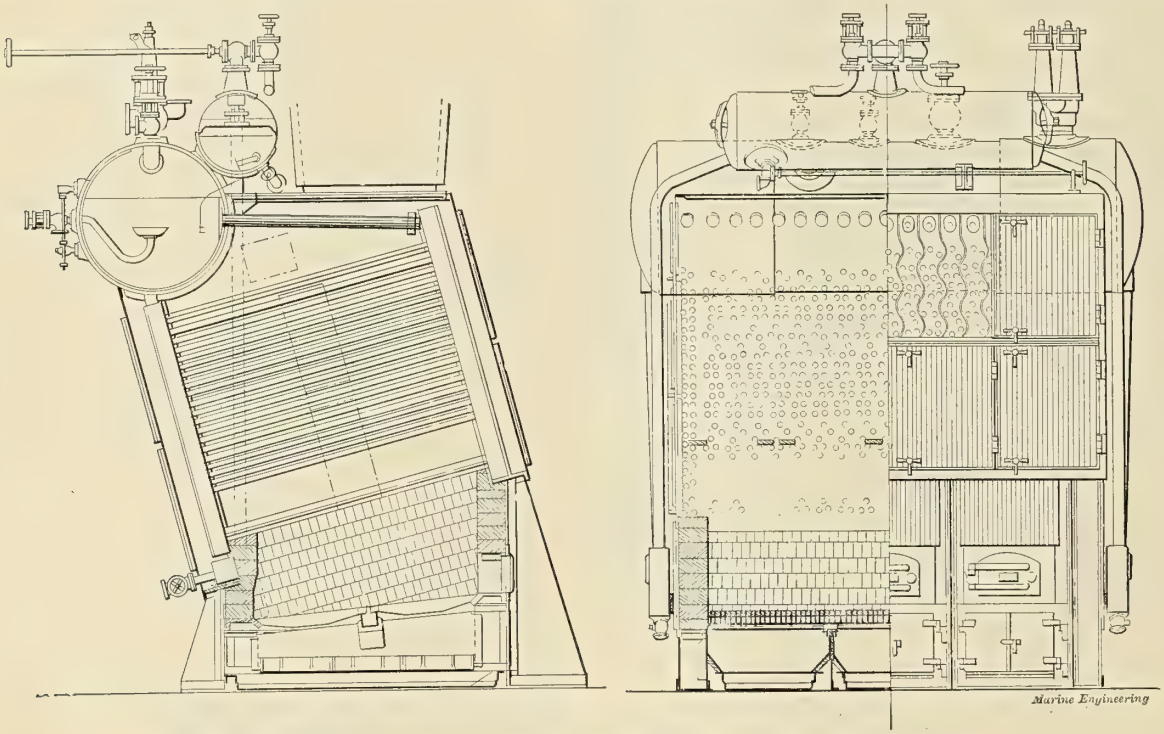
Babcock & Wilcox Marine Boiler.

This boiler is a modification of the old and widely known stationary water tube boiler, which has been in use both here and abroad for more than a quarter of a century. For marine use it has been made in various forms or modifications of one well defined type, and the boiler which we here illustrate is designed for ordinary passenger and cargo steamers. This boiler is of the large, straight submerged tube type. It consists of a series of water tubes, inclined at an angle of about 15 deg. to the horizontal, expanded at the ends in vertical sinuous headers of square or box section. The tubes enter the headers at right angles, and the upper ends are at the front of the boiler. The headers are laid side by side across the front and back of the boiler in pairs, each pair being connected with an inclined row of tubes. The upper ends of the front set of headers project above the top row of water tubes, and are connected with the steam and water drum by horizontal pipes at about the water level. This drum is of large diameter, and is placed over the top of the back set of headers. A short length of pipe connects the bottom of the drum with each of these headers. Each side of the boiler is composed of an inclined row of tubes forming part of the heating surface. Below the water tubes the furnaces are formed of brickwork or fire tiles, and the whole boiler is contained in the usual casing with non-conducting lining. Each of the back headers is connected by a short length of pipe with a mud "drum" of rectangular section, which extends across the back of the boiler at the lowest point reached by the contained water. To the form of boiler here illustrated a feed water purifier and heater is fitted. This consists of a drum of smaller diameter than the steam drum, placed in front of and alongside the latter, and about half way between its horizontal and vertical axes. The feed water enters the top of this subsidary drum midway of its length, and falls in the form of a cascade by means of suitable baffle plates. It is heated by coming into contact with live steam, which is admitted to the purifier by a connection with the steam drum. In the lower half of the feed drum there are a number of diaphragm plates, over which the water passes on its way to the outlet pipes at the ends of the drum. These pipes carry the feed after it has parted with impurities down to the mud drum of the boiler, before referred to. A blow-off is fitted at the bottom of the feed drum, which can be used to clean out the sediment when necessary. When in operation steam is generated in the inclined water tubes, which receive the heat direct from the furnace, and the mixture of steam and water rises in the "uptake" headers at the front of the boiler. From there it passes into the drum by the horizontal tubes, connecting the front headers with the drum, where the steam is liberated and drawn off through the dry pipe in the top of the drum. The return flow is by way of "downtake," or back headers, to the tubes again, and so a continuous circulation is main-

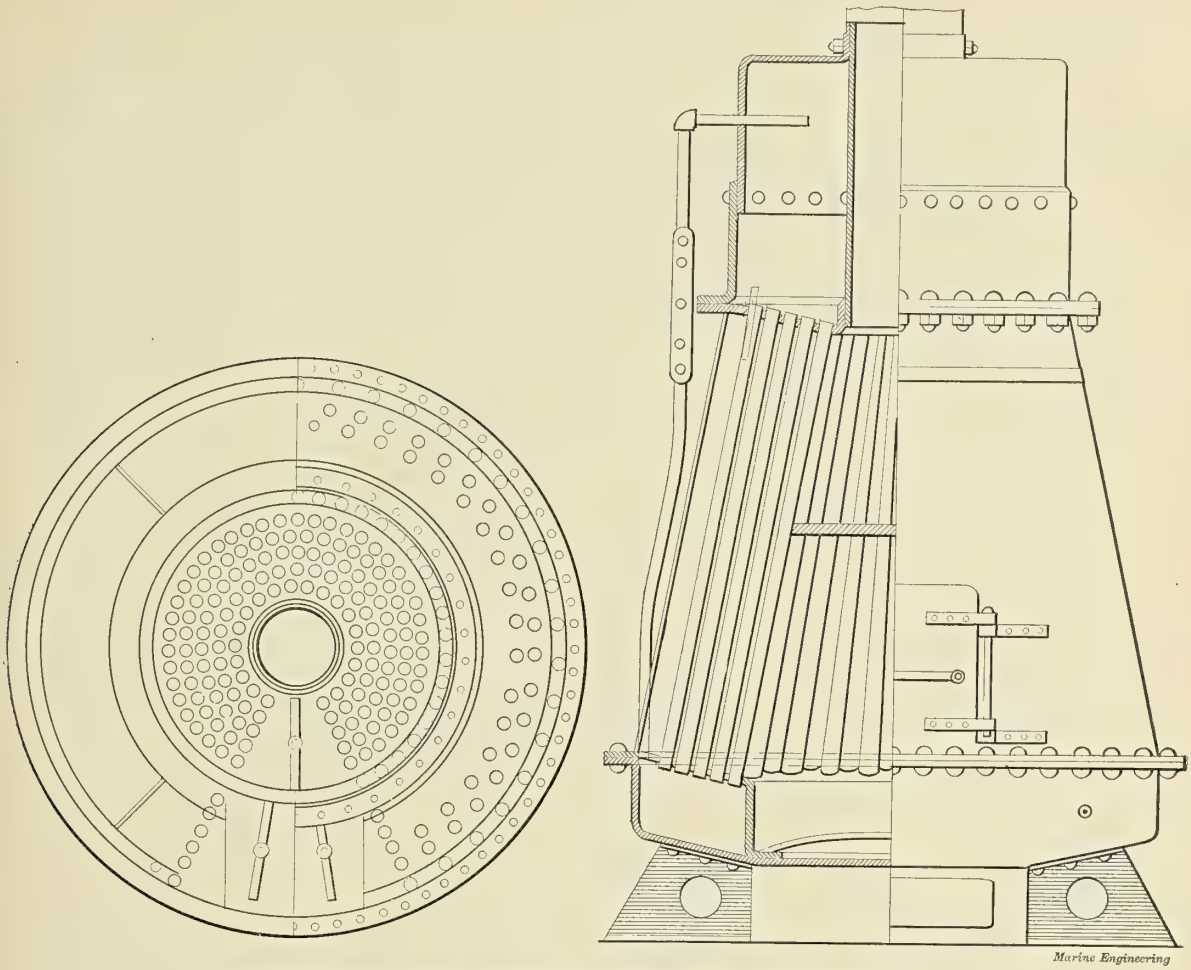
tained. This boiler is constructed wholly of wrought steel. All the generating tube ends are expanded by the ordinary roller expander, and the interior of these tubes can be easily examined and cleaned by the removal of plugs in the headers opposite the ends. Boilers of this general type have been fitted in several merchant vessels on the ocean and Great Lakes, and also in a number of war vessels. In the U. S. Navy they have been already installed or ordered for these ships: *Atlanta, Annapolis, Chicago, Cincinnati, Marietta,* and *Wyoming,* and (stationary type) for the monitors *Canonicus, Mahopac,* and *Manhattan.* They are built in this country by the Babcock & Wilcox Co., 29 Cortlandt street, New York.

Watson Radial Water Tube Boiler.

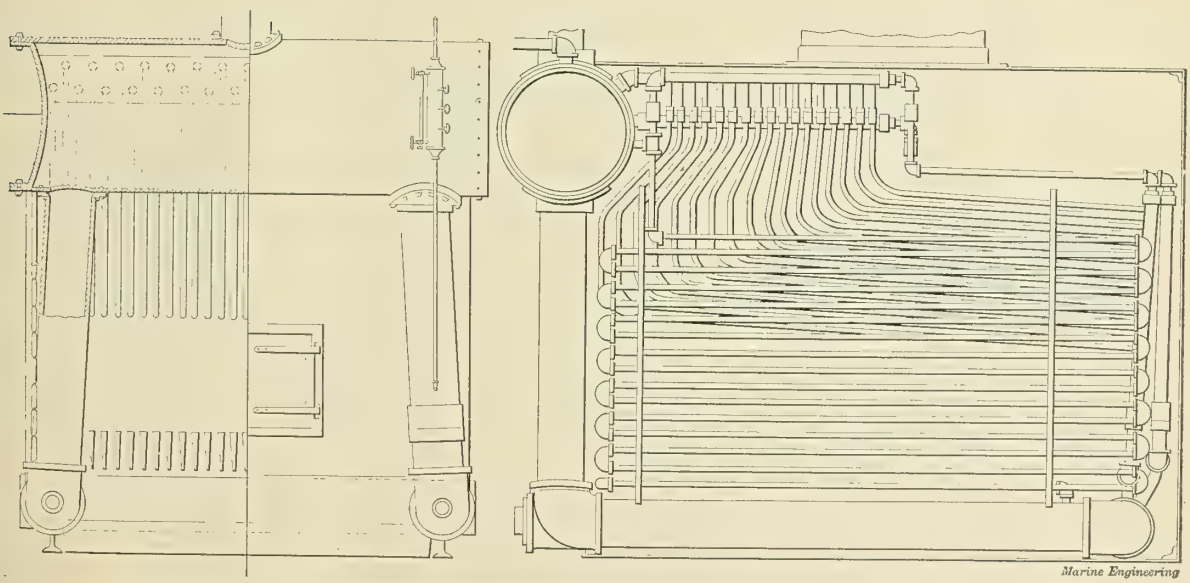
In construction the Watson radial water tube boiler differs considerably from most of the other marine boilers on the market. Its general outlines, when set up ready for use are those of a truncated cone. As shown in the drawings, the tube system is in the form of a cone, inclined over a central furnace, the tubes being straight and expanded at the upper ends into the steam dome, and at the lower ends into the water bottom or reservoir. The tube sheets are inclined so that the tubes enter them practically at right angles. At the bottom the tubes are very widely spaced, and as they converge at the top the spacing is proportionally narrowed here, an arrangement which helps to break up the gases and facilitate combustion. A baffle plate is placed in the upper part of the combustion chamber, directly under the smoke pipe. The latter is in the vertical axis of the boiler and is connected to the upper tube sheet by a screwed joint at the lower end. Where it emerges from the steam dome a metallic slip joint is used, with bolts passing through the neck of the joint at right angles. The water bottom is forged (dished) from one sheet of steel with a circular opening in the center for the reception of the grate, the bars of which are put in through the furnace door. Joints between the lower tube sheet and the shell of the water bottom are riveted and caulked. A cone shaped, sheet steel, air tight diaphragm extends from top to bottom between the rows of tubes designated as steam tubes, and the circulating or down flow tubes, with, of course, an opening for the fire door. Riveted joints are used to connect the various elements as described, with the exception of the flanged joint between the upper tube sheet and the bottom of the water and steam dome. This joint is made with bolts and nuts, and can be readily broken for inspection, cleaning, or repair, such as replacing a tube. In this boiler the circulation when under steam is very rapid. In operation the gases of combustion are deflected among the tubes when they strike the baffle plate on their way from the furnace to the stack. The inner rows of tubes are exposed to the greatest intensity of the heat, and in these the water rises from the bottom reservoir to the dome. Outside the diaphragm, before referred to, the rows of tubes are comparatively cool, and in these the water flows in the contrary direction. The hotter the fire the more rapid the circulation. Solids in suspension in the feed water are carried down to the water bottom and are taken care of by use of the sediment cock. The water is carried well above the tops of the tubes, so that when in operation they are all submerged. In the upper part of the dome the dry pipe encircles the smoke pipe. All material entering into the construction of this boiler is carefully inspected; the tube sheets and dome are of 60,000 lb. T. S. steel, and the tubes are solid drawn. A steel ash pit is bolted to the water bottom, and can be readily re-



SECTIONAL DRAWINGS OF THE BABCOCK & WILCOX MARINE TYPE WATER TUBE BOILER.



SECTIONAL PLAN AND ELEVATION OF WATSON RADIAL WATER TUBE BOILER.



DRAWINGS OF THE BOYER SECTIONAL WATER TUBE BOILER.

moved and replaced. It is claimed for this boiler that it is light in weight and occupies little space, while at the same time having large heating surface and grate area. It also has a low center of gravity. The contained water is about 30 per cent of the total weight of the boiler. The inventor and manufacturer is Egbert Pomeroy Watson, Elizabeth, N. J.

Boyer Water Tube Boiler.

This boiler is of the sectional small bent tube type. It consists of a steam and water drum placed across the front end of the boiler at the top. From the bottom of this drum at each end large down-flow pipes are carried, outside the front casing, to horizontal water legs situated below the level of the grate, these legs extending along the two sides and back end of the boiler. The water legs at the sides are not directly connected to the series of small tubes forming the generating system. From the water leg at the back there rises a double row of vertical tubes or manifolds to a height of about the water level in the drum. From these vertical manifolds the generating tubes extend, with a slight upward inclination toward the front of the boiler, the lowest row of tubes forming the furnace crown. This row extends the entire length of the boiler from front to back, turning upward—inside the front casing—in an easy bend, each tube terminating in a horizontal manifold, which connects at the front end with the drum above the water level. The successive rows of generating tubes are spaced somewhat widely apart in their vertical direction and this brings the topmost row to a connection with the upper manifold, about half the length of the boiler from front to back. Alternate sections of the generating tubes, or "generating flats," as they are termed, connect with horizontal manifolds at a different level. There are two rows of these horizontal manifolds, one entering the drum a short distance above the other, and both above the water line. The back ends of the horizontal manifolds are connected with the top ends of the vertical manifolds at the back by independent tubes or relief pipes, L shaped, and fitted with screwed connections—this is done to prevent dead ends. Across the top of these relief pipes a coil is laid, through which the feed is passed on its way to the horizontal water legs. At each side of the firebox, inside the casing, a row of horizontal tubes, with screwed connections at the ends, is carried from the level of the grate to a point considerably above the furnace crown. At the bottom the row on each side connects with the side leg, and at the top with the steam drum. These details will be clear upon an inspection of the accompanying drawings. It will be noticed that all the small tubes are exposed to the action of the fire, and in these the flow is upward. The down-flow pipes carry the water from the drum to the horizontal water legs, and from there it passes into the vertical manifolds, and thence into the generating system. In operation the gases pass directly over the generating tubes on their way from the furnace to the smoke outlet, which is the center of the top of the boiler. The boilers are built to conform to United States inspection rules, and all the pipes, tubes and fittings used are commercial sizes, such as can be purchased in the open market. The boiler is manufactured by the patentees, L. Boyer's Sons, 90 Wall street, New York.

Stranding of British Sailing Ship.

Residents of the New Jersey coast in the vicinity of Point Pleasant, were treated to the spectacle of a four masted steel sailing ship high, and practically dry, on the beach last month. The vessel, named the *County of Edinburgh*, had almost completed the long voyage from Cape Town to New York, in ballast, when she went ashore in a dense fog February 12. In the photograph, the position of the vessel is plainly seen, with visitors alongside who had walked out to the ship across the sands. Several days after the mishap the crew came ashore, as the vessel was pounding heavily under the influence of the tide and a strong northwest wind. At this time of writing the ship is still fast on the sand, and it is believed that a channel will have to be dredged to get her afloat again, unless she can be lightened sufficiently to float during the next spring tide. The *County of Edinburgh* is a steel ship built in 1885 by Barclay Curle & Co., of Glasgow, Scotland, and she is owned by R. & J. Craig. Her dimensions are: Length, 285 ft.; beam, 42 ft.; depth, 24 ft. Her gross tonnage is 2,160 tons. The ship was under charter to the Standard Oil Co.

Naphtha Launch Saves Steamship.—An unusual decoration has just been added to the 21 ft. naphtha launch *Sachem*, owned by Frederick T. Adams, of New York. It takes the form of a silver plate with an inscription recording its presentation by the underwriters and the New York & Puerto Rico S.S. Co., to the owner, for services rendered by his launch to the S.S. *Ponce*, while in distress off Tybee Island, Ga., in October, 1899. The plate was affixed to the wood work of the launch at the yard of the builders, the Gas Engine & Power Co., and Charles L. Seabury & Co., Con., New York. It was on the maiden trip of the new S.S. *Ponce* that the incident that has this pleasant sequel took place. The steamer left New York for Puerto Rico October 19, with passengers and cargo; among the former being Frederick T. Adams, who brought with him the launch *Sachem*, and the engineer Alex. Ingraves. The *Ponce* met bad weather and when two days out lost her propeller. Sea anchors were got out and the vessel kept bows on to the seas, and finally help came, with a Dutch steamer, which towed the *Ponce* for two days. The weather was getting worse all the time and the vessels parted company. As the condition of the *Ponce* in the prevailing weather was serious, Captain Dyer decided to try and communicate with the shore, less than 50 miles distant. He asked Mr. Adams for the loan of the launch, which was freely granted, and Captain Dyer, with the assistance of the launch's engineer and members of the crew of the *Ponce*—six in all—set out for help. A tremendous sea was running and a gale blowing, but the launch made good headway and put the party ashore at Tybee Island, Ga., in about seven hours. From there the assistance of tugs from Savannah was secured, and the *Ponce* was finally towed into port.

At the annual meeting of the New York Yacht Club held last month, Lewis Cass Ledyard was elected commodore for the ensuing year. As a consequence, for the first time in a number of years, a sailing yacht will be the flagship of the club.

BRITISH SAILING SHIP, COUNTY OF EDINBURGH ASHORE ON COAST OF NEW JERSEY. SEE PAGE 126.

MARINE ENGINEERING

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Copy for changes in advertisements must be in our hands not later than the 20th of the month to insure changes being made in the issue of the month following, and not later than the 15th of the month if corrected proof is to be submitted.

RESULTS of a careful enumeration of the steel vessels under construction at shipyards on the seacoast of the United States, in the month of January, 1900, have recently been published by the United States Bureau of Navigation. Commissioner E. T. Chamberlain, chief of the bureau, has been engaged in some useful work of late in furthering the interests of the American merchant marine, and the tables just referred to are part of the campaign of education. To those who have not occasion to keep in close touch with the work in the coast yards these official figures must be surprising in magnitude. In all instances it was not possible to secure complete returns, so that there are probably some errors of omission, but nevertheless the total merchant tonnage recorded was little short of 200,000 tons. Additional to this there are fifty war vessels under construction at coast yards of a total of 140,313 tons displacement. This, it must be remembered, takes no account of the large amount of tonnage under construction on the Great Lakes, nor the considerable number of vessels now under construction on our rivers and other inland waters. The lake tonnage on which work is now going forward amounts to about 185,000 tons, and the river yards are very fully occupied, many of the vessels being of the largest size. For the coast and lakes we have then a grand total of more than 500,000 tons under construction. A significant fact, as showing the trend of progress, is that a very considerable amount of this tonnage is first-class full-powered steel construction, designed and equipped in accordance with modern ideas. One group under this head consists of ten steamships, of 81,600 tons, now being built at coast yards for foreign trade, all of the vessels being eligible for subsidy under the ocean mail act of 1891. These vessels include: Two steamers of 11,300 tons for the Pacific Mail; two steamers of 12,000 tons for the International Navigation Co.; three steamers of 7,000 tons for the Oceanic Steamship Co., and three steamers of 4,000 tons for the New York and Cuba Mail. There are also four large freight steamers of 8,000 tons for the new line to the Hawaiian Islands. For the coasting trade there are forty-five steel vessels under construction of a total of 76,000 gross tons. In one yard alone (Newport News) there was, in one stage or another of construction, the enormous total of 102,680 tons, when the list was prepared. At Cramps' the total was about 90,000 tons. The figures given here do not, of course, represent the annual capacity of the various yards, as they include vessels in all conditions, from those just contracted for to those which have undergone their steam trials. At the same time, however, they show the condition of activity which prevails, giving employment to tens of thousands of persons and necessitating the expenditure of a tremendous sum in the aggregate for finished materials. Since the introduction of steam no such activity has before been experienced, and it only needs the helpful aid of Congress to speedily develop this outgrowth of the nation's commercial energy many fold.

IN connection with the maintenance of a large fleet of naval vessels in Asiatic waters, there is no more pressing need than the creation there of proper docking facilities. The acquisition of the Philippine Islands makes it possible to establish such in American waters. There are at present no facilities for docking vessels—other than the very smallest—in our new possessions, and consequently, our warships have to make the long sea voyage to Hong Kong to go into dock. The extra cost and time involved are serious enough, but not nearly as serious as the fact that these docks are under the control of a foreign, if friendly, power. In

case of a war—a possibility, though not a probability—in which Britain would be obliged to remain neutral, the efficiency, or even safety, of our vessels in those waters would be seriously threatened. In the late war, owing to a combination of fortunate circumstances, our vessels in the Orient did not suffer greatly for lack of such facilities; but the outcome of that war did not grant us immunity from serious injury in perpetuity. Long before the Manila fight the Spanish Government recognized this very need and made a contract with a concern at Newcastle-on-Tyne, England, for the construction of a floating dock for the port of Olongapo, P. I. Work on this dock was begun and carried forward, but before completion the Spanish-American war had broken out and delivery was never made. We understand that this dock has since been completed and is now for sale at the builder's yard. According to authentic reports at the time the contract was let, the dock was to be of large size, capable of lifting any vessel up to 500 ft. long, and 12,000 tons displacement. It was to be self docking and equipped in all respects according to the best modern practice. The dock was to be built in sections so that it could be readily shipped to its destination and there finally put together. A dock of these dimensions can hardly be classed as a readily salable article, and it is not unlikely that it could be purchased by the United States Government at a reasonable price, though on this point we have no information whatever. It would certainly not be very long before the cost of such a dock would be expended in sending our naval vessels to Hong Kong and paying docking charges there. If, all things considered, the purchase of this particular dock was inadvisable, the authorization by Congress for the immediate construction here of a floating dock for the Philippines would seem to be a very necessary act.

PUBLISHED returns of the world's shipbuilding during 1899 show a grand total of merchant vessels of 2,122,000 tons, of which 1,946,000 tons were steam and 176,000 tons sail. In these columns last month we gave a summary of the British returns which, as is customary, are the largest. Next in amount of output comes the United States with 225,000 tons, a very considerable increase over the tonnage put out during the year preceding (1898). Germany comes third, but not far behind, with 211,000 tons; France fourth, with 90,000 tons, and Italy's total foots up nearly 50,000 tons. It is noticeable how small the percentage of sail tonnage has become of the total output. In 1899 there was not a single sailing ship built in the United Kingdom, and but for the additions made by France to the sail tonnage the total would have been considerably less. Under the stimulus of State aid the French built no less than twenty-four sailing vessels, none of less than 2,000 tons, and the largest exceeding 3,000 tons. Outside the United Kingdom the total number of mercantile vessels built was 292 steamers of 530,945 tons, and 251 sailing vessels of 174,002 tons, and the total of war vessels was 56 of 176,170 tons displacement. During the year the total amount of tonnage lost, broken up, or otherwise removed from trade, was 727,000 tons; made up of 345,000 tons of steam vessels and 382,000 of sailing vessels. This means the decrease of all sail tonnage, throughout the world, by about 200,000 tons, and the increase of steam tonnage by about 1,600,000 tons.

AN announcement was made by the trustees of Columbia University last month that the decision had been reached to establish courses in marine engineering and naval architecture in the School of Mechanical Engineering. Coupled with this was the very extraordinary public statement, attributed to President Seth Low, that he "shared the opinion of the faculty that it is highly important for the University to pre-empt the field of marine engineering without delay." We can hardly believe that President Low was quoted correctly, for such a choice of expression, as ordinarily understood, would imply either an astounding ignorance of facts, or a desire of the faculty to slight two of the most successful and honored scientific schools the world over—the Massachusetts Institute of Technology, and Sibley College, Cornell University. In both these technical colleges courses of study in naval architecture and marine engineering have long been established, and have been the means of educating a corps of young men, the influence of whose training is now being felt most beneficially in the upbuilding of the American merchant marine. In a quiet, unostentatious way these splendid schools are doing a work which, when their graduates shall have matured and risen to places of executive responsibility, will go a long way toward establishing this country as the foremost shipbuilding nation in the world.

EDUCATIONAL DEPARTMENT.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—BOILERS—V.

BY DR. WILLIAM FREDERICK DURAND.

§3. CORROSION. [Continued.]

The possibility of deposits of copper on boiler surfaces has been already mentioned. These were first noted in connection with the corrosion accompanying the general introduction of the surface condenser. It was believed that the copper of the condenser tubes was attacked by the pure water resulting from the condensation of the steam, or by the fatty acids formed as above explained, and was then carried over into the boiler and deposited on the surfaces. To prevent such action the condenser tubes were tinned, thus covering the copper from the action of the water or the fatty acids. Neither this step nor the substitution of hydrocarbon oil for that containing fatty acids has made any very marked difference in boiler pitting, and at the most the presence of the copper can have been only one among a number of causes as suggested.

There has been much difference of opinion and difference in experience regarding the question whether wrought iron or steel boiler tubes were the more liable to corrosion. It was pointed out that wrought iron was less homogeneous than steel, and therefore the latter should be the better. The early experience with steel hardly bore out this claim, and in fact the general opinion seems to have been that wrought iron tubes were found to corrode less readily than steel. In explanation of this, it may be said that while wrought iron was less homogeneous physically, the steel was perhaps less homogeneous chemically, and in any event contained a larger proportion of carbon than the iron, so that it would by no means follow that it would necessarily be less subject to electro-chemical action. The latest and best products of the steel makers for such purposes, however, are extraordinarily low in carbon and very homogeneous, and experience with such grades of material seems to show them superior to wrought iron in this respect.

We have thus developed in some detail the causes of corrosion on the water side of steam boilers, so far as they are understood. For the prevention of such effects their causes must be removed or counteracted.

For reducing the amount of oxidation and the possible results due to electro-chemical action, the presence of air in the feed water must be avoided by preventing as far as possible the entrance of water from overboard into the feed. The hot-well or feed-tank should also be of good size and kept full, so that there may be no danger of its getting too low from time to time, and thus allowing the pump to take air. The piston rod on the low pressure cylinder should be kept well packed, so as to prevent the entrance of air during the exhaust part of the stroke. The feed pump rods on the water end should be kept well packed for the same reason.

To prevent acid corrosion the formation of the acids must be prevented as far as possible, and such as may form must be neutralized within the boiler. The prevention of the formation of fatty acids has been considered above. We have also seen that the formation of other acids is due chiefly to the presence of salts contained in sea water, or to organic substances. We have therefore simply an additional reason for keeping all such substances out of the boiler as far as possible. To neutralize such acid as may form, bicarbonate of soda, or soda-ash, as it is known in the trade, may be used from time to time, and in such quantities as may be found necessary. To test the water for acidity the litmus test is used. Blue litmus paper turns red when dipped in water slightly acid, while if the water is alkaline it remains blue, or the red color caused by an acid is changed to blue. By this means the condition of the water may be tested from time to time and soda used accordingly. Care must be taken not to use it in too great excess, as it may cause foaming. The soda is introduced by means of a soda cock on the condenser. Instead of keeping the water alkaline by the use of soda, dependence is often placed on the zinc slabs used to prevent electro-chemical corrosion. These are gradually dissolved, forming zinc chloride, and this will undoubtedly tend to neutralize free acids and to keep the water alkaline. Whether sufficient or not, can of course be readily determined by the litmus test before referred to.

For the prevention of electro-chemical action the causes must also be removed or neutralized as far as possible. This cannot be realized entirely, but it is clear that the results will be the better as the following conditions are the more nearly fulfilled:

(1) The structure of the boiler should be of material as homogeneous as possible in its chemical constitution and physical condition.

(2) Causes liable to produce oxidation or the presence of foreign substances should be kept out of the boiler as far as possible.

(3) The water in the boiler should be made as nearly neutral or non-exciting relative to the iron as possible. This in a general way will be attained by keeping it slightly alkaline rather than acid, and by avoiding very high densities.

In addition to these means for reducing the causes, there remains one further step, and that is:

(4) The provision of a substance which shall be electro-positive to iron, and readily attacked, so that the activity will be diverted from the iron to the protecting substance, and the operation will proceed at the expense of the latter rather than of the former. Such a substance we find in zinc, and its use for this purpose is very general and seemingly beneficial.

It may be also noted that the formation of zinc chloride as referred to in the foregoing will aid in keeping the water alkaline in reaction, thus reducing its natural activity, and contributing further to the general decrease of electro-chemical action.

In order to be effective as a protection to the iron in the manner described, the zinc must be in actual metallic contact with the structure of the boiler. It is usually in the form of rolled or cast slabs, weighing 8 to 12 lbs. each. These are often placed in perforated sheet metal baskets hung from the stays or attached to other portions of the boiler. Where the basket is attached to the boiler there should be *bright metal* contact, and the attachment should be by screwed joint or other equivalent means, so that the separation of the two surfaces by

the formation of scale or corrosion between them may be prevented. The zinc should also be connected to the basket by through bolts or other means which will insure continuous metallic contact. In some cases the zincs are hung by a through bolt without other means of support. In such case, as the zinc becomes used it may fall apart and the pieces may lodge where they will obstruct the circulation, or be otherwise undesirable. In any event they will no longer protect the part of the boiler confided to their care, and their period of usefulness may therefore be less than when supported and connected to a basket as described above. The number of zincs fitted varies greatly according to the judgment of different engineers. In some cases not more than 10 or 12 would be assigned to the protection of a large double end boiler, while in others as many as 40 or 50 would be used. The latter number is the better representative of good modern practice. In any case they should be distributed as nearly uniformly as possible throughout the boiler, in order that the latter may be thus subdivided into parts, each more especially under the influence of a given slab.

Instead of depending on zinc to prevent or divert electro-chemical action, as above described, some engineers prefer to depend simply on reducing the activity of the water by keeping it alkaline by the use of soda, introduced as the litmus test may show to be necessary.

When spots are found in a boiler, showing the presence of pronounced corrosion, they should be cleaned off thoroughly, washed with soda solution, and, if not on a heating surface, covered with a thin wash of Portland cement. This will attach itself to the iron and protect it in a manner similar to the lime scale.

The beneficial effect of scale in thus protecting the surfaces of boilers from corrosion is well recognized, and there is no doubt that its presence as a thin wash or layer is of great value. In order to be effective, however, it must be so firmly and closely attached to the iron as to prevent contact of the water with the surface, else the corrosive action may proceed under the scale and result all the more seriously because it is protected from inspection until the scale is thoroughly removed. On the tubes and other heating surfaces of the boiler with their changes of temperature and consequent expansions and contractions, the scale is especially liable to be cracked off or partially separated from the iron, with possible results as here noted. This is still more likely to be the case as the scale becomes thicker and the metal more liable to become overheated. It has also been suggested that a very heavy scale may result in an overheating of the metal sufficient to decompose the moisture present, thus liberating oxygen and forming the magnetic oxide of iron or black mill scale (Fe_3O_4). This is highly electro-negative to iron, and thus it may give rise to harmful electro-chemical reactions.

Laying Up Boilers.—When boilers are to be laid up, the principles already explained will indicate the nature of the means suitable for preventing corrosion.

On the outside, paint or other like coating may be used as already noted. On the fire side of water-tube boilers protection is sometimes gained by building a slow fire of tar or resinous material, the tarry smoke from which condenses on the tubes and furnishes protection from the air with its moisture and carbon dioxide. Use is also made of quicklime in trays renewed from time to time. This absorbs the moisture and so keeps the air dry.

On the inside, all boilers when laid up should be either empty or entirely full. If a boiler stands for any considerable length of time partly full, corrosion is likely to occur about the water line. If they are to be out of use for a short time only, they may be filled full of water made slightly alkaline by the addition of soda, the condition of the water being determined by the litmus test already referred to. If they are to be laid up for a longer time it is better to lay them up dry. To this end the water is removed, the manhole-plates taken off and the interior thoroughly dried out by the introduction of trays of burning charcoal or coke. The boiler is then closed up except a lower manhole through which a tray of freshly burning charcoal is introduced, and the manhole cover is put on. The charcoal will consume most of the remaining oxygen, and the boiler will thus be protected. Instead of the final introduction of a tray of charcoal, trays of quicklime may be used to insure the absence of all moisture, and the boiler then closed as before.

It is readily seen that these various methods are simply ways of carrying out the necessary conditions for preventing oxidation, as already discussed, and if these principles are kept clearly in view, the means most conveniently at hand may be suitably adapted to provide the protection desired.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE—XXII.

BY WM. BAXTER, JR.

METHODS OF DISTRIBUTION.—CONTINUED.

In the last article several arrangements were shown for connecting the distributing mains with the generator terminals, and the manner in which calculations are made were also briefly outlined. Although only a few examples were given, these should be sufficient to enable any one to apply the principles to any case, for the course of procedure is always the same. Stating the rule in as few words as possible, we can say that to obtain the resistance in ohms of any feeder all we have to do is to divide the volts by the amperes. If we desire to transmit any given current over a line we first determine what loss of pressure can be allowed; that is, what the line drop must be, then we divide this drop in volts by the current, and the result is the resistance of the line. As a rule, it is desirable to keep the line loss as low as possible so as to not waste power, for all the volts absorbed by the line resistance represent just so much coal burned for which no light is given. In many cases, however, the loss of energy in the lines is not of so much importance as the obtaining of uniform voltage at the lamps, hence in deciding what particular type of connection to use these matters have to be considered, but after the plan of wiring has been decided upon the process by which the resistance of the wire is obtained is the same.

In the last figure of the last article we showed a method of connecting the distributing mains with the generator in such a way as to be able to deliver a higher pressure at the distant lamps than when a single con-

nection is made, and it was pointed out that by the plan shown the voltage supplied to the lamps the furthest from the generator could be greater than that

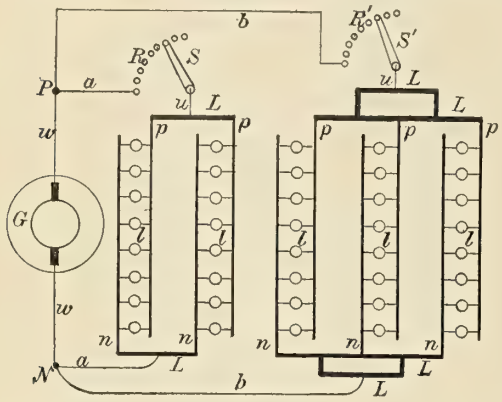


FIG. 140.

of those near by. In Fig. 140, here presented, an extension of the same principle is shown in which the

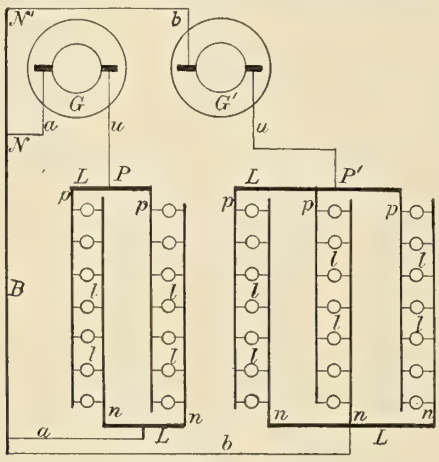


FIG. 141.

voltage delivered to the lamps can be increased or decreased as desired. In some cases it is necessary to

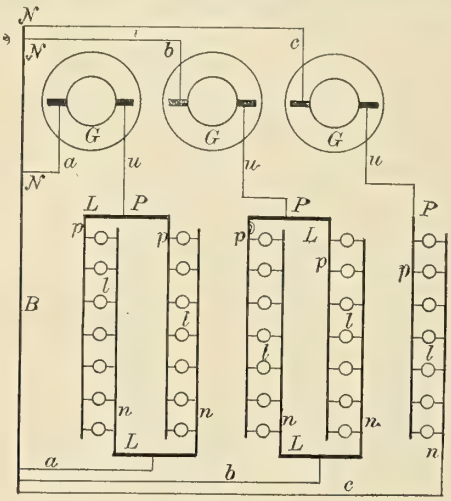


FIG. 142.

arrange lamps so that they may be dimmed without being turned out. To accomplish this all that is required is to reduce the voltage acting upon the lamps, and the simplest way of doing it, when there is only one generator in use, is by introducing extra resistance into the circuit. Thus, in the figure, if we desire to dim the lights in the first and second groups, we turn the switch S so as to cut into the current a portion of the resistance of the rheostat R. In the same way if we desire to dim the last three groups we cut in a portion of rheostat R'. This arrangement is

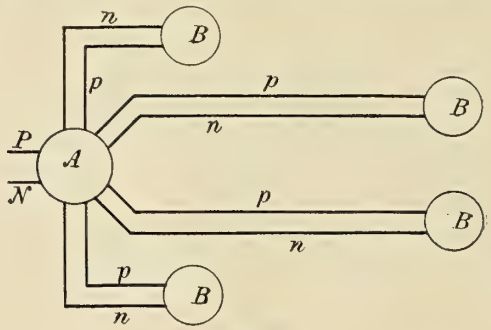


FIG. 143.

not generally liked by engineers, as the introduction of resistance into the circuit involves a waste of energy, but, after all, the waste is not so much as at first might be supposed, for including the portion absorbed by the resistance, the energy supplied to the circuit is less than when no resistance is used. To illustrate, suppose we have sixteen lamps in the first two groups,

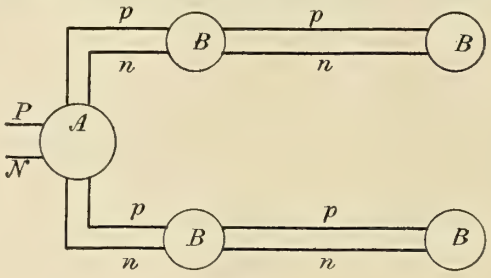


FIG. 144.

taking one-half of an ampere each, making a total of 8 amperes. Let the resistance of each lamp be 224 ohms, then the resistance of the whole number will be 14 ohms, since $224 \div 16 = 14$. Let the resistance of the lines between the terminals PN and the lamps be one-eighth of an ohm, then the pressure of the generator at P and N must be 113 volts, and the lamps will receive 112 volts. Now, suppose we introduce as much resistance of rheostat R as may be necessary to cut the current down to six amperes, we will then find

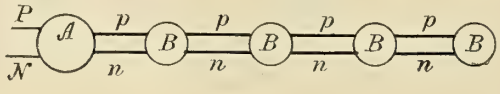


FIG. 145.

that the total circuit resistance has increased to about 18.8 ohms, and of this amount the rheostat supplies about 4.7 ohms, or say, 25 per cent. With the current at 8 amperes, the energy supplied to the circuit will be 113 volts $\times$ 8 amperes $=$ 904 watts, and with the current at 6 amperes it will be three-quarters of this amount or 678 watts, and the portion lost in the rheostat will be 169 watts. Thus we save 226 watts of energy, but

to effect the saving we throw away in the rheostat 169 watts; that is, if we could cut the current down without using the rheostat we could save this 169 watts also. If we have two or more generators we can ac-

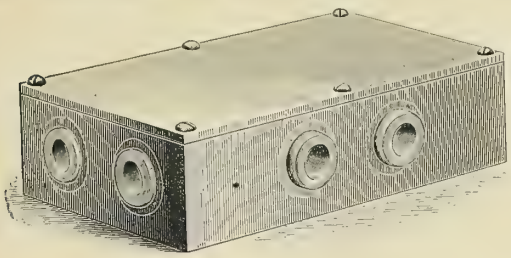


FIG. 146.

complish the last result by resorting to the type of connection shown in Fig. 141. With this arrangement, as the two generators are only connected to the same circuit on one side, the voltage of either one can be changed without affecting the other one; hence, if we wish to dim the lights in the circuits fed by either machine, all we have to do is to reduce its voltage. This

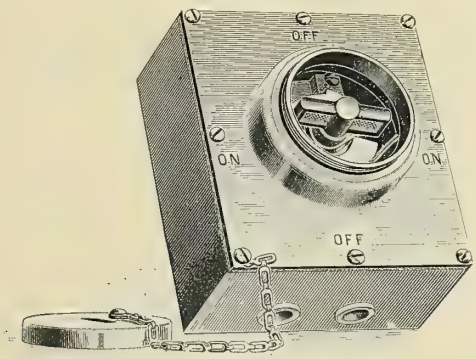


FIG. 147.

we can accomplish by means of the field regulator, in the manner explained in previous articles. The plan shown in Fig. 141 can also be made use of to reduce the size of wire for the lamps situated at a distance from the generators, because the machine G' can be adjusted to run at a higher voltage than the other one, the difference being made as much as the length of circuits may demand. In any case, however, only a slight difference will be required; thus if the G machine develops a pressure of 110 volts between P and N, the other generator may develop 112 between N' and P'.

If there are three generators, as in Fig. 142, they can be arranged as shown, so as to divide the system of circuits into three sets, and then each machine can be set for a slightly different pressure. Even if the difference in voltage is great it will make no difference in the running of the machines, providing there is no chance for one circuit to be crossed by the other; but if the wires run in such a way that those of one set are liable to come in contact with those of another set, there is a possibility of damage being done, as then the high pressure current would run back through the

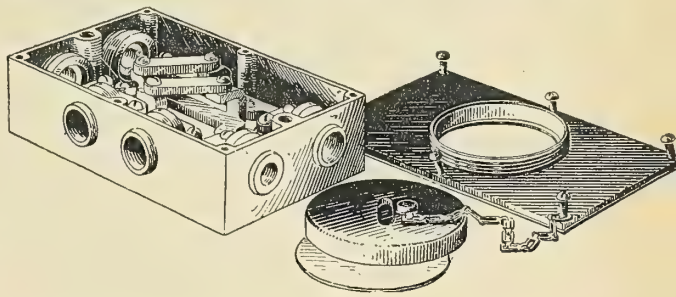


FIG. 148.

generator delivering the low pressure and under certain conditions the results would be disastrous.

Although a certain amount of wire can be saved by dividing the system of circuits into sections, and feeding each one from a different generator, with the pressure increased slightly, for those supplying the more distant sections, the plan is not a desirable one, all things considered, as the saving is effected at the expense of reliability. If all the generators feed into the same system, at the same pressure, the disabling of one machine will not stop any particular section, but at the

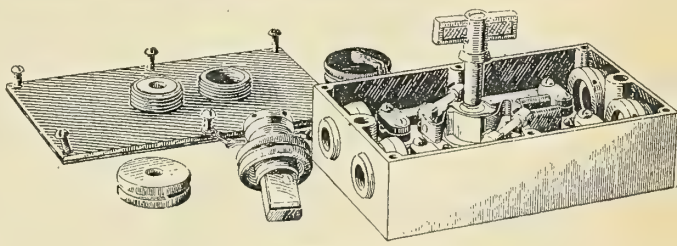


FIG. 149.

most will cause a slight reduction all around. With the generators arranged as in Figs. 141 and 142 the whole system can be thrown into one whenever desired by equalizing the pressure of all the machines, and then making the necessary connections at the switchboard. If this is done, however, the lamps on the distant portions of the lines, which are arranged to operate with

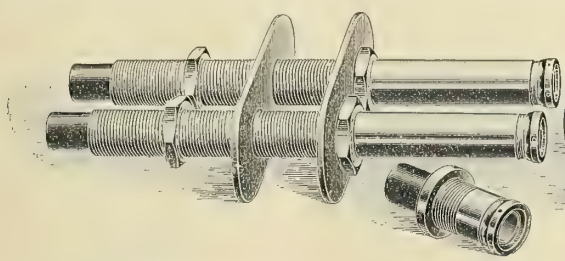


FIG. 150.

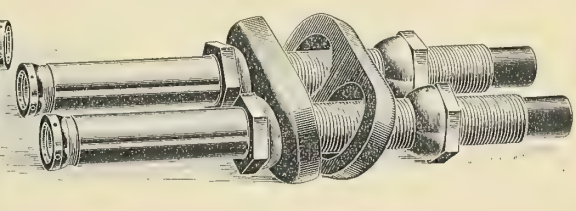


FIG. 151.

FIG. 152.

a higher pressure, will be decidedly dimmer than the normal.

In distributing currents over large networks of wires, it is necessary to use a considerable amount of ingenuity to not get them so mixed up that they be-

come a hopeless puzzle. The safest way to avoid such a condition of things is by concentrating the various branch lines into centers of distribution, thus laying out the entire system much after the manner in which the branches of a tree lead out from the trunk. These centers are variously called distributing boxes, junction boxes, distributing panels and panel boards. The general arrangement of these can be understood from Figs. 143 and 145. In the first, figure *A* represents a main distributing box, which is connected with the switchboard by means of the mains *P* and *N*. From this box circuits *p n* run out to the secondary boxes *B B*, which latter form centers from which the lines that feed the lamps are run. The box *A* as well as boxes *B B* may be very simple affairs, or they may be diminutive switchboards. If of the simple type, the main lines *P N* of box *A* may be connected with the four circuits *n p*, with fuse wires in one or both of the wires of each secondary circuit. In this case the overloading of any one of the branches will melt a fuse at *A*, and this fact being known, if the current fails, this portion of the system is at once examined and a new fuse put in. The box *A* may be provided, in addition to the fuses, with switches, by means of which the current may be cut off from any circuit, and then from this point the lamps operated from the boxes *B B* can be controlled. The secondary boxes *B B*, if provided only with fuses, cannot be used to control the individual circuits leading out to the lamps, and in that case they serve principally as receptacles for the safety fuses of the several lamp circuits. If these boxes are provided with switches to control the several lamp circuits, then from them all the lights operating in any one branch can be turned on or off by the movement of a single switch.

Generally it is desired to so arrange the wiring that each circuit will be as nearly independent of all the others as is possible, and to accomplish this result the lines *p n* are run out directly to the *B B B B* boxes, as in Fig. 143; that is, each box is on a separate circuit. Sometimes it is not desirable or practicable, for one reason or another, to run out individual circuits to each secondary box, and in such cases they can be arranged as in Fig. 144 with two boxes in series in each circuit, or as in Fig. 145 with all the boxes in series in the same circuit. This last arrangement would not be adopted very often unless there were one or more lamp circuits running out of *A*, as well as the *n p* circuit running to the secondary boxes. If there were no such additional circuits, the mains from the switchboard might just as well run directly to the first *B* box, and thus dispense with the *A* box.

The distributing boxes and switches used in marine work are made water tight, whenever this construction is practicable, which is almost always the case when they are not complicated, and therefore not large. Large panel boards with many switches have to be made much the same as those used in other lines of work, though, of course, these can be enclosed in protecting cases.

Figs 146 to 154 show several designs of distribution boxes, switches and brushings for running lines through decks and bulkheads, made by the General Electric Co., specially for marine work. Fig. 146 is a simple junction box. Fig. 147 is a double pole switch of the water tight type. Fig. 148 is a similar type of box that is provided with outlets for two distributing circuits. Fig. 149 is a junction box provided with a switch and a plug to take off the distributing circuit. Fig. 150 shows the construction of a main deck stuffing tube, another design being shown in Fig. 152. Fig. 151 is a bulkhead stuffing box for a single wire; the other tubes are arranged in pairs, but can as well be made single.

ENGINEERS' DICTIONARY.—XXV.

Joint—In its general sense, any form of fastening or mode of connecting parts of a machine or engineering structure. Where the parts are to move one relative to the other, some form of *pin, hinge* or *toggle* joint is employed. For stationary parts the term may refer to some particular mode of fastening, as a *bolted* joint or a *riveted* joint, of which there are many varieties. Reference may also be made to some particular mode of preparing the surfaces or making the joint tight against leakage, as a *ground* joint, in which the surfaces are fitted, the one to the other, by grinding them together with some abrasive between, as ground glass or fine emery; or again, a *scraped* joint, in which the surfaces are carefully prepared by hand scraping and dressing until an accurate fit is obtained. The joints between a cylinder head and cylinder, boiler manhole covers and their seats, various bonnets and their seats, etc., are usually made tight with some form of sheet packing, compressed by the fastenings, though occasionally a wire or gasket of copper or other soft metal is employed.

Journal—That portion of a shaft which is supported in the bearing. Care should be had to distinguish between the *journal* which turns and the *bearing* which supports.

Junk Ring—In early engineering practice the name given to the FOLLOWER PLATE (which see). This name was applied because in early practice pistons were made tight by junk or hemp packing secured by this ring.

Key—A bar of metal used as a fastening for securing one piece to another, as, for example, the eccentric sheave on the crank-shaft, the propeller on the tail-shaft, or, with a gib, the connecting-rod-strap to the rod. See under ECCENTRIC, Fig. 51, and also under GIB.

Keyway—The groove cut for the insertion of the key, partly in each of the two pieces to be secured together. See Fig. 51.

Kingston Valve—A name given to the injection or inlet valve for any pump which draws water from the sea, or more especially to the inlet valve for the main circulating pump.

Knot.—The unit of *speed* usually employed in all maritime and naval matters. A speed of one knot is equivalent to a speed of one *nautical mile* per hour. The nautical mile is somewhat differently defined in different countries. Thus in Great Britain it is 6,080 feet. In the United States it is defined as the length of one minute of arc on a great circle of a sphere having the same area as the earth. With the accepted values this gives a length of 6,080.27 feet. The difference between the English and American values is unimportant for ordinary engineering purposes. Taking 6,080 ft. as the

value, it follows that a speed of one knot will represent 6,080 ft. per hour, or 101.33 ft. per minute. To reduce knots to feet per minute we may, therefore, multiply by 101.33. It should not be forgotten that the term *knot* signifies in itself a speed, and that the phrase *knots per hour* is unnecessary. A speed of "15 knots" is the correct way of speaking, rather than "15 knots per hour."

Lagging—A covering placed about steam cylinders, valve chests, steam pipes and boilers, to prevent the escape of heat and often to add a finished appearance to the object thus covered. Steam cylinders and valve chests are usually lagged with strips of wood. In small engines they are sometimes covered with polished brass. Steam pipes, boilers, etc., are usually covered with some one of the many varieties of felt or similar non-combustible material. See FELT.

Lap—When a slide valve is in mid position, as shown in Fig. 84, the amount *AC*, by which the edge of the valve extends beyond the edge of the port on the steam side is called the *steam lap,* and similarly the amount

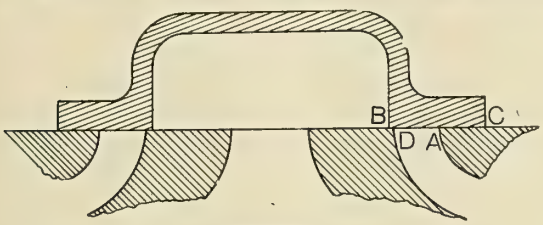


FIG. 84.

BD, by which the edge of the valve extends over the port on the exhaust side is called the *exhaust lap.* While the lap is usually the same at both ends of the valve, this is by no means necessarily the case, and in the most careful designs they are usually different at the two ends.

Lap Joint—One of the varieties of riveted joint in which the two plates lap over each other.

Latent Heat—Heat which is absorbed by a body without effecting a change of temperature. When, for example, heat is applied to water at an ordinary temperature, the first effect is to raise the temperature until the boiling point is reached. At this point the temperature remains stationary and a further addition of heat effects a gradual change of state from water to steam at the same temperature. The heat which is thus absorbed in effecting a change of state is known as *latent.* In a similar way heat is absorbed and rendered latent by the melting of ice, and, in fact, by the passage of practically all bodies from solid to liquid, and from liquid to vapor. The amount of latent heat for the change of water to steam varies with the temperature of the boiling point, and is one of the quantities given in steam tables for the use of engineers. At atmospheric pressure it is 966 heat units, the unit being the amount of heat required to raise the temperature of water one degree, or, more exactly, from 62° to 63° Fah.

Lazy Bar—A bar placed across the opening of the furnace or ash-pit upon which the firing tools are rested in working the fire.

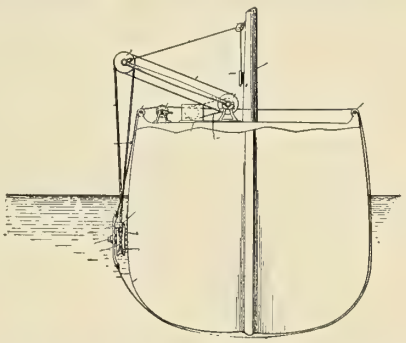
In an 80-page book bound in flexible covers the Power Publishing Co. has issued a reprint of a series of lectures and articles on the subject of condensers, which have appeared in the columns of *Power.* The price is only 50 cents.

SELECTED MARINE PATENTS.

(Subscribers are notified that the publication of a patent specification in this column does not indicate editorial commendation or condemnation.)

633,873. Apparatus for cleaning hulls of vessels. David Mason, New York, N. Y.

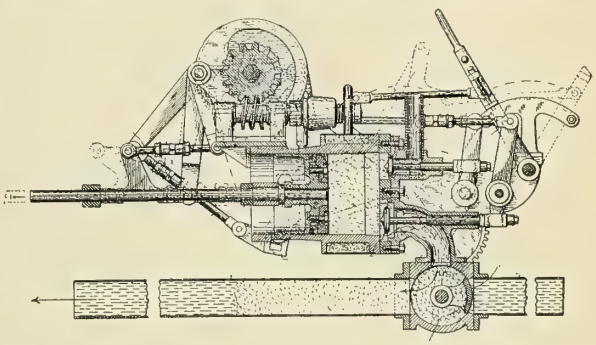
CLAIM.—A rotary disc carrying scraping points is supported against the hull by ropes passing entirely around the vessel. Belt gearing connects the disk with



a motor on the deck of the vessel, so as to impart a rotary motion thereto and cause the points to remove all barnacles from the hull.

634,217. Means for marine propulsion. J. A. Secor, New York, N. Y.

CLAIM.—Propels the vessel by means of the reactionary force of an explosive gas, acting on water in a conduit extending fore and aft the vessel. The explosion-cylinder communicates with the conduit and the force



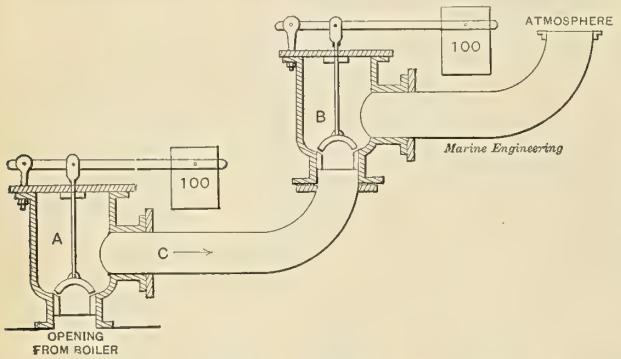
of the explosion drives the water from the conduit. An arrangement of valves and operating mechanism opens the conduit to fill the same while the charge of gas is being drawn in and compressed, so that the greater period of time in the cycle of operation is used to prepare the gas and water for action.

Any one engaged in hydrographic work will find the book entitled "Practical Nautical Surveying and the Handicraft of Navigation," by Commander Thomas A. Hull, R. N., a most valuable assistant. This work of 60-odd pages first appeared as a reprint of two papers read before the Royal United Service Institution in London by the author, and the demand for it was such that the papers have been re-written and issued in the present convenient form. It contains a great deal of valuable information, up-to-date and easy of comprehension. This book—price 3 shillings—is published by J. D. Potter, Admiralty Chart Agent, 31 Poultry, London, E. C., England.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—Referring to the accompanying sketch, will you please say at what pressure the safety valves would blow off? These are the dimensions of each: Area of valve opening, 12 in.; center of weight to center of



fulcrum, 36 in.; weight of ball, 100 lb.; weight of valve and stem, 10 lb.; weight of lever, 40 lb.; distance of fulcrum to valve, 5 in. INQUIRER.

A.—With the arrangement you figure, each valve, alone, would blow off at about 73 lbs. With the two valves together the valve *A* will first rise at about this pressure and admit a little steam into the space *C* between the valves. As soon as the pressure in *C* rises slightly, the valve *A* will seat itself and remain until the pressure in the boiler again rises, so that the difference between the pressure in the boiler and in *C* is 73 lbs. In this way the pressures in the boiler and in *C* would gradually rise, their difference keeping at about 73 lbs., until finally when the pressure in *C* is about 73 lbs. and that in the boiler about 146 lbs. the valve *B* will open as well, and there will be an escape of steam to the atmosphere. It would thus appear that if the pressure in the boiler were maintained at about 146 lbs. the pressure in *C* would hold at about 73 lbs., and both valves would blow off more or less regularly, and thus discharge the steam into the air.

Q.—A small launch, L. W. L., 23 ft.; beam, 3 ft. 6 in.; draft, 2 ft., is driven by two 15-in. dia., 30-in. pitch, wheels running at 800 revolutions. They are on the same shaft turning against each other. Will you please tell me whether the speed is figured as one wheel, or if there is a different formula? The boat is so designed in the buttocks that when the bow rises at extreme speed she comes on to a level bottom. The immersed form is designed to offer least resistance, the water lines being extremely fine. I figure out that one wheel will give 16.78 knots, using only 15 per cent. slip. G. S. R.

A.—The information which you give is not sufficient for a satisfactory examination of the problem. The I. H. P. proposed or developed is not given, nor the fore and aft distance between the wheels, nor the nature of the connection between the two motors.

You are correct in saying that a wheel of 30 in. pitch with 15 per cent. slip and making 800 revolutions per minute would drive the boat about 16.8 knots. The question is, however, whether one 15-in. propeller or two such propellers as described in your letter, would be able, even if the necessary power were provided, to develop the thrust necessary to drive a boat of the size given at such a speed with only 15 per cent. slip. It is one thing to specify diameter, pitch, revolutions and resulting speed, but quite a different one to realize it all in practice.

It is very sure that one such propeller would not, nor is it at all likely that two rigged as you describe would be able to realize the conditions imposed, and develop the speed mentioned. There is little or no public experimental data available for estimating the propulsive thrust of propellers coupled up as you describe, and it is not a matter which can be safely figured from the performance of the same propellers singly. In any event, however, it would appear that for the given wheels and revolutions you are probably expecting too much speed, or for the given speed and slip your wheels are far too small.

It is also probable that you could do better with two propellers on the same shaft run in the same rather than in opposite directions, and very possibly also by the use of different pitches and diameters instead of the same. All this is, however, practically unknown ground in the problem of propulsion, and advance can be made only by the gradual accumulation of reliable data through experimental trial.

Q.—Will you kindly explain, through your query column, the caliber of a gun? For example, a "5-in. 50 caliber gun?" W. E. J.

A.—The caliber of a gun means the diameter of the bore. Thus in the phrase a "5 in. 50 caliber gun" the caliber or diameter of the bore is 5 in. The term "50 caliber" refers to the *length* of the bore, and means that its total length is 50 calibers, or 50 times 5 in. It has become customary in modern ordnance to express the length of bore in terms of the caliber, and thus we have had 30 caliber guns, 40 caliber guns, etc., meaning in each case a length of bore of 30, 40, etc., times the caliber.

This answers the question, but a few additional points may be of interest.

The bore of modern ordnance is, of course, rifled. The depressions are termed *grooves* and the intermediate spaces *lands*. The caliber is the diameter of the circle just touching the lands, and is therefore less than the diameter of a circle bounding the bottom of the grooves. In other words, the caliber is the diameter of the original hole before rifling.

The calibers used in U. S. Naval ordnance are 13 in., 12-in., 10-in., 8-in., 6-in., 5-in. and 4-in. Below about 4-in. caliber the gun is usually referred to by weight of projectile, and in U. S. Naval ordnance we have the 12-pounder of about 3 in. caliber, the 6-pounder of about 2.3 in. caliber, the 3-pounder of about 1.8 in. caliber and the 1-pounder of about 1.5 in. caliber. In countries other than England and the United States the caliber is expressed in the metric system and usually in centimeters for large ordnance, and in millimeters for rapid-fire and small guns. Many of the latter are found in the U. S. Naval ordnance. Thus the 37 mm. gun corresponds to the 1-pounder, the 47 mm. to the 3-pounder, while the 53 mm. throws a shell of about 4 lb. weight.

For a convenient and simple approximate relation between the calibre in inches and the weight of the projectile in pounds we may use the following:

Rule.—Cube the caliber in inches and divide by 2. The result will give the approximate weight of projectile in pounds.

Thus for the 6-in. gun the cube is 216 and ½ of this is 108, while the actual weight of projectile is 100.

Referring again to the length of gun, there has been in recent years a constant increase in length corresponding to the demand for increasing muzzle velocities. About 15 years ago, when the first of the new naval ordnance was built, muzzle velocities of about 2,000 ft. per second were the highest in use, and the length was commonly about 30 calibers. Now the development of a higher velocity at the muzzle means one or both of two things: (1) A higher pressure developed in the gun and hence a greater force acting on the projectile; (2) a longer time during which the force may act. The pressure which can be allowed cannot, however, be increased much beyond the present limits of from 15 to 17 tons per square inch, so that increasing velocities must depend largely on a greater time of action on the projectile, and this means a longer bore within which to allow such increased action. At the same time much depends on the powder, which should be such as to keep up a constant evolution of gas and thus follow up the projectile as nearly as may be with the full pressure so long as it remains in the gun. This requirement led first to the change from black powder to the brown or slow burning powder, the purpose being to obtain a powder in which the rate of combustion could be controlled by the composition, size, density and form of grain, so as to insure the continuance of the full accelerating force as just stated. The still more modern chemical or smokeless powders fulfil still more completely the same requirement, and have the additional advantage of making little or no perceptible smoke.

The latest guns designed for U. S. Naval ordnance are of about 50 calibers length, and with smokeless powder the expectation is a muzzle velocity of about 3,000 ft. per second.